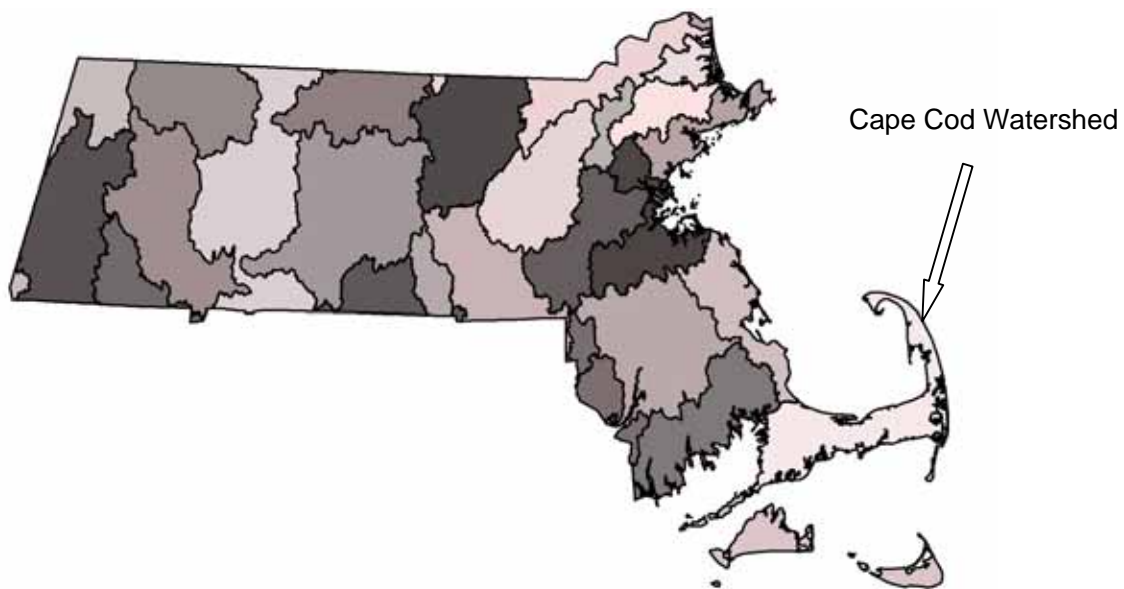


Draft Pathogen TMDL for the Cape Cod Watershed



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NOTICE OF AVAILABILITY

Limited copies of this report are available at no cost by written request to:

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This report is also available from MADEP's home page on the World Wide Web.

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DISCLAIMER

References to trade names, commercial products, manufacturers, or distributors in this report constituted neither endorsement nor recommendations by the Division of Watershed Management for use.

Much of this document was prepared using text and general guidance from the previously approved Neponset River Basin and the Palmer River Basin Bacteria Total Maximum Daily Load documents.

Acknowledgement

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Draft Total Maximum Daily Loads for Pathogens within the Cape Cod Watershed



Key Features:

Pathogen TMDL for the Cape Cod Watershed

Location:

EPA Region 1

Land Type:

New England Coastal

303(d) Listings:

Pathogens

Back River (MA95-47); Barnstable Harbor (MA96-01); Bass River (MA96-12); Boat Meadow River (MA96-15); Bournes Pond (MA96-57); Bucks Creek (MA96-44); Bumps River (MA96-02); Cape Cod Canal (MA95-14); Centerville River (MA96-04); Chase Garden Creek (MA96-35); Cotuit Bay (MA96-63); Duck Creek (MA96-32); Eel Pond (MA95-48); Falmouth Inner Harbor (MA96-17); Great Harbor (MA96-18); Great Pond (MA96-54); Great Pond (MA96-55); Great Sippewisset Creek (MA95-23); Hamblin Pond (MA96-58); Harbor Head (MA95-46); Harding Beach Pond (MA96-43); Herring Brook (MA95-21); Herring River (MA96-22); Herring River (MA96-33); Hyannis Harbor (MA96-05); Lewis Bay (MA96-36); Little Harbor (MA96-19); Little Namskaket Creek (MA96-26); Little River (MA96-61); Little Sippewisset Marsh (MA95-24); Maraspin Creek (MA96-06); Mashpee River (MA96-24); Mill Creek (MA96-37); Mill Creek (MA96-41); Namskaket Creek (MA96-27); North Bay (MA96-66); Oyster Pond (MA96-45); Oyster Pond (MA96-62); Oyster Pond River (MA96-46); Pamet River (MA96-31); Parkers River (MA96-38); Perch Pond (MA96-53); Phinneys Harbor (MA95-15); Pocasset Harbor (MA95-17); Pocasset River (MA95-16); Popponesset Creek (MA96-39); Prince Cove (MA96-07); Provincetown Harbor (MA96-29); Quashnet River (MA96-20); Quissett Harbor (MA95-25); Quivett Creek (MA96-09); Red Brook Harbor (MA95-18); Red Lily Pond (MA96257); Rock Harbor Creek (MA96-16); Ryder Cove (MA96-50); Saquatucket Harbor (MA96-23); Scorton Creek (MA96-30); Seapuit River (MA96-64); Sesuit Creek (MA96-13); Shoestring Bay (MA96-08); Stage Harbor (MA96-11);

Swan Pond River (MA96-14); Taylors Pond (MA96-42); Waquoit Bay (MA96-21); Wellfleet Harbor (MA96-34); West Falmouth Harbor (MA95-22).

Data Sources:

- EOEa “*Cape Cod Watershed Assessment and 5-Year Action Plan*”
- MADEP “*Cape Cod Water Quality Assessment Report*”
- MADEP “*Buzzards Bay Watershed 2000 Water Quality Assessment Report*”
- MACZM “*Atlas of Stormwater Discharges in the Buzzards Bay Watershed*”
- Cape Cod Commission “*Cape Cod Comprehensive Regional Wastewater Management Strategy Development Project*”

Data Mechanism: Massachusetts Surface Water Quality Standards for Fecal Coliform; The Federal BEACH Act; Massachusetts Department of Public Health Bathing Beaches; Massachusetts Division of Marine Fisheries Shellfish Sanitation and Management; Massachusetts Coastal Zone Management

Monitoring Plan: Massachusetts Watershed Five-Year Cycle

Control Measures: Watershed Management; Storm Water Management (e.g., illicit discharge removals, public education/behavior modification); No Discharge Areas; BMPs; By-laws; Ordinances; Septic System Maintenance/Upgrades

Executive Summary

Purpose and Intended Audience

This document provides a framework to address bacterial and other fecal-related pollution in surface waters of Massachusetts. Fecal contamination of our surface waters is most often a direct result of the improper management of human wastes, excrement from barnyard animals, pet feces and agricultural applications of manure. It can also result from large congregations of birds such as geese and gulls. Illicit discharges of boat waste are of particular concern in coastal areas. Inappropriate disposal of human and animal wastes can degrade aquatic ecosystems and negatively affect public health. Fecal contamination can also result in closures of shellfish beds, beaches, swimming holes and drinking water supplies. The closure of such important public resources can erode quality of life and diminish property values.

Who should read this document?

The following groups and individuals can benefit from the information in this report:

- a) towns and municipalities, especially Phase I and Phase II storm water communities, that are required by law to address storm water and other sources of contamination (e.g., broken sewerage pipes and illicit connections) that contribute to a waterbody's failure to meet Massachusetts Water Quality Standards for pathogens;
- b) watershed groups that wish to pursue funding to identify and/or mitigate sources of pathogens in their watersheds;
- c) harbormasters, public health officials and/or municipalities that are responsible for monitoring, enforcing or otherwise mitigating fecal contamination that results in beach and/or shellfish closures or results in the failure of other surface waters to meet Massachusetts standards for pathogens;
- d) citizens that wish to become more aware of pollution issues and may be interested in helping build local support for funding remediation measures.

TMDL Overview

The Massachusetts Department of Environmental Protection (MADEP) is responsible for monitoring the waters of the Commonwealth, identifying those waters that are impaired, and developing a plan to bring them back into compliance with the Massachusetts Water Quality Standards (WQS). The list of impaired waters, better known as the "303d list" identifies problem lakes, coastal waters and specific segments of rivers and streams and the reason for impairment.

Once a water body is identified as impaired, the MADEP is required by the Federal Clean Water Act (CWA) to develop a “pollution budget” designed to restore the health of the impaired body of water. The process of developing this budget, generally referred to as a Total Maximum Daily Load (TMDL), includes identifying the source(s) of the pollutant from direct discharges (point sources) and indirect discharges (non-point sources), determining the maximum amount of the pollutant that can be discharged to a specific water body to meet water quality standards, and assigning pollutant load allocations to the sources. A plan to implement the necessary pollutant reductions is essential to the ultimate achievement of meeting the water quality standards.

Pathogen TMDL: This report represents a TMDL for pathogen indicators (e.g. fecal coliform, *E. coli*, and enterococcus bacteria) in the Cape Cod Bay Watershed, except Muddy Creek (MA96-51) and Frost Fish Creek (MA96-49) as TMDLs were prepared previously for these segments in 2004 and approved in 2005. Certain bacteria, such as coliform, *E. coli*, and enterococcus bacteria, are indicators of contamination from sewage and/or the feces of warm-blooded wildlife (mammals and birds). Such contamination may pose a risk to human health. Therefore, in order to prevent further degradation in water quality and to ensure that waterbodies within the watershed meet state water quality standards, the TMDL establishes indicator bacteria limits and outlines corrective actions to achieve that goal.

Sources of indicator bacteria in the Cape Cod watershed were found to be many and varied. Most of the bacteria sources are believed to be storm water related. Table ES-1 provides a general compilation of likely bacteria sources in the Cape Cod watershed including failing septic systems, certain recreational activities, wildlife including birds along with domestic pets and animals, storm water outfall pipes and direct overland storm water runoff. Note that bacteria from wildlife would be considered a natural condition unless some form of human inducement, such as feeding, is causing congregation of wild birds or animals. A discussion of pathogen related control measures and best management practices are provided in the companion document: “*Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts*”.

This TMDL applies to the 66 pathogen impaired segments of the Cape Cod watershed that are currently listed on the CWA § 303(d) list of impaired waters. MADEP recommends however, that the information contained in this TMDL guide management activities for all other waters throughout the watershed to help maintain and protect existing water quality. For these non-impaired waters, Massachusetts is proposing “pollution prevention TMDLs” consistent with CWA § 303(d)(3).

The analyses conducted for the pathogen impaired segments in this TMDL would apply to the non-impaired segments, since the sources and their characteristics are equivalent. The waste load and/or load allocation for each source and designated use would be the same as specified herein. Therefore, the pollution prevention TMDLs would have identical waste load and load allocations based on the sources present and the designated use of the water body segment (see Table ES-1 and Table 6-1).

This Cape Cod watershed TMDL may, in appropriate circumstances, also apply to segments that are listed for pathogen impairment in subsequent Massachusetts CWA § 303(d) Integrated List of Waters. For such segments, this TMDL may apply if, after listing the waters for pathogen impairment and taking into account all relevant comments submitted on the CWA § 303(d) list, the Commonwealth determines with EPA approval of the CWA § 303(d) list that this TMDL should apply to future pathogen impaired segments.

Since accurate estimates of existing sources are generally unavailable, it is difficult to estimate the pollutant reductions for specific sources. For the illicit sources, the goal is complete elimination (100% reduction). However, overall wet weather indicator bacteria load reductions can be estimated using typical storm water bacteria concentrations. These data indicate that in general two to three orders of magnitude (i.e., greater than 90%) reductions in storm water fecal coliform loading will be necessary, especially in developed areas. This goal is expected to be accomplished through implementation of best management practices, such as those associated with the Phase II control program for storm water.

TMDL goals for each type of bacteria source are provided in Table ES-1. Municipalities are the primary responsible parties for eliminating many of these sources. TMDL implementation to achieve these goals should be an iterative process with selection and implementation of mitigation measures followed by monitoring to determine the extent of water quality improvement realized. Recommended TMDL implementation measures include identification and elimination of prohibited sources such as leaky or improperly connected sanitary sewer flows and best management practices to mitigate storm water runoff volume. Certain towns in the watershed are classified as Urban Areas by the United States Census Bureau and are subject to the Stormwater Phase II Final Rule that requires the development and implementation of an illicit discharge detection and elimination plan.

In most cases, authority to regulate non-point source pollution and thus successful implementation of this TMDL is limited to local government entities and will require cooperative support from local volunteers, watershed associations, and local officials in municipal government. Those activities can take the form of expanded education, obtaining and/or providing funding, and possibly local enforcement. In some cases, such as subsurface disposal of wastewater from homes, the Commonwealth provides the framework, but the administration occurs on the local level. Among federal and state funds to help implement this TMDL are, on a competitive basis, the Non-Point Source Control (CWA Section 319) Grants, Water Quality (CWA Section 604(b)) Grants, and the State Revolving (Loan) Fund Program (SRF). Most financial aid requires some local match as well. The programs mentioned are administered through the MADEP. Additional funding and resources available to assist local officials and community groups can be referenced within the Massachusetts Non-point Source Management Plan-Volume I Strategic Summary (2000) "Section VII Funding / Community Resources". This document is available on the MADEP's website at: www.state.ma.us/dep/brp/wm/wmpubs.htm, or by contacting the MADEP's Nonpoint Source Program at (508) 792-7470 to request a copy.

Table ES-1. Sources and Expectations for Limiting Bacterial Contamination in the Cape Cod Watershed

Surface Water Classification	Pathogen Source	Waste Load Allocation Indicator Bacteria (CFU/100 mL)¹	Load Allocation Indicator Bacteria (CFU/100 mL)¹
A, B, SA, SB	Illicit discharges to storm drains	0	N/A
A, B, SA, SB	Leaking sanitary sewer lines	0	N/A
A, B, SA, SB	Failing septic systems	N/A	0
A	NPDES – WWTP	Not to exceed an arithmetic mean of 20 organisms in any set of representative samples, nor shall 10% of the samples exceed 100 organisms ²	N/A
A	Storm water runoff Phase I and II	Not to exceed an arithmetic mean of 20 organisms in any set of representative samples nor shall 10% of the samples exceed 100 organisms ³	N/A
A	Direct storm water runoff not regulated by NPDES and livestock, wildlife & pets	N/A	Not to exceed an arithmetic mean of 20 organisms in any set of representative samples, nor shall 10% of the samples exceed 100 organisms ³
B & Not Designated for Shellfishing SA & SB	NPDES – WWTP	Shall not exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms ²	N/A
B & Not Designated for Shellfishing SA & SB	Storm water runoff Phase I and II	Not to exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms ³	N/A
B & Not Designated for Shellfishing SA & SB	Direct storm water runoff not regulated by NPDES and livestock, wildlife & pets	N/A	Not to exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms ³

Surface Water Classification	Pathogen Source	Waste Load Allocation Indicator Bacteria (CFU/100 mL)¹	Load Allocation Indicator Bacteria (CFU/100 mL)¹
SA Designated Shellfishing Areas	NPDES – WWTP	Not to exceed a geometric mean of 14 organisms in any set of representative samples, nor shall 10% of the samples exceed 43 organisms ²	N/A
SA Designated Shellfishing Areas	Storm water Runoff Phase I and II	Not to exceed a geometric mean of 14 organisms in any set of representative samples, nor shall 10% of the samples exceed 43 organisms ³	N/A
SA Designated Shellfishing Areas	Direct storm water runoff not regulated by NPDES and livestock, wildlife & pets	N/A	Not to exceed a geometric mean of 14 organisms in any set of representative samples, nor shall 10% of the samples exceed 43 organisms ³
SB Designated Shellfishing Areas	NPDES – WWTP	Not to exceed a geometric mean of 88 organisms in any set of representative samples, nor shall 10% of the samples exceed 260 organisms ²	N/A
SB Designated Shellfishing Areas	Storm water runoff Phase I and II	Not to exceed a geometric mean of 88 organisms in any set of representative samples, nor shall 10% of the samples exceed 260 organisms ³	N/A
SB Designated Shellfishing Areas	Direct storm water runoff not regulated by NPDES and livestock, wildlife & pets	N/A	Not to exceed a geometric mean of 88 organisms in any set of representative samples, nor shall 10% of the samples exceed 260 organisms ³
No Discharge Areas	Vessels – raw or treated sanitary waste	0	N/A
Marine Beaches ⁴	All Sources	Enterococci not to exceed a geometric mean of 35 colonies in a statistically significant number of samples, nor shall any single sample exceed 104 colonies	Enterococci not to exceed a geometric mean of 35 colonies in a statistically significant number of samples, nor shall any single sample exceed 104 colonies

Surface Water Classification	Pathogen Source	Waste Load Allocation Indicator Bacteria (CFU/100 mL) ¹	Load Allocation Indicator Bacteria (CFU/100 mL) ¹
Fresh Water Beaches ⁵	All Sources	<p>Enterococci not to exceed a geometric mean of 33 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 61 colonies</p> <p>OR</p> <p><i>E. coli</i> not to exceed a geometric mean of 126 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 235 colonies</p>	<p>Enterococci not to exceed a geometric mean of 33 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 61 colonies</p> <p>OR</p> <p><i>E. coli</i> not to exceed a geometric mean of 126 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 235 colonies</p>

N/A means not applicable

¹ Waste Load Allocation (WLA) and Load Allocation (LA) refer to fecal coliform densities unless specified in table.

² Or shall be consistent with the Waste Water Treatment Plant (WWTP) National Pollutant Discharge Elimination System (NPDES) permit.

³The expectation for WLAs and LAs for storm water discharges is that they will be achieved through the implementation of BMPs and other controls.

⁴ Federal Beaches Environmental Assessment and Coastal Health Act of 2000 (BEACH Act) Water Quality Criteria

⁵ Massachusetts Department of Public Health regulations (105 CMR Section 445)

Note: this table represents waste load and load reductions based on water quality standards current as of the publication date of these TMDLs, any future changes made to the Massachusetts water quality standards will become the governing water quality standards for these TMDLs.

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1.0 Introduction

Section 303(d) of the Federal Clean Water Act (CWA) and Environmental Protection Agencies (EPA's) Water Quality Planning and Management Regulations (40 CFR Part 130) require states to place waterbodies that do not meet established water quality standards on a list of impaired waterbodies (commonly referred to as the "303d List") and to develop Total Maximum Daily Loads (TMDLs) for listed waters and the pollutant(s) contributing to the impairment. In Massachusetts, impaired waterbodies are included in Category 5 of the "*Massachusetts Year 2002 Integrated List of Water: Part 2- Final Listing of Individual Categories of Waters*" (2002 List; MADEP 2003a). Figure 1-1 provides a map of the Cape Cod watershed with pathogen impaired segments indicated. Please note that not all segments have been assessed by the Massachusetts Department of Environmental Protection (MADEP) for pathogen impairment. As shown in Figure 1-1, much of the Cape Cod waterbodies are listed as a Category 5 "impaired or threatened for one or more uses and requiring a TMDL" due to excessive indicator bacteria concentrations.

TMDLs are to be developed for water bodies that are not meeting designated uses under technology-based controls only. TMDLs determine the amount of a pollutant that a waterbody can safely assimilate without violating water quality standards. The TMDL process establishes the maximum allowable loading of pollutants or other quantifiable parameters for a water body based on the relationship between pollutant sources and instream conditions. The TMDL process is designed to assist states and watershed stakeholders in the implementation of water quality-based controls specifically targeted to identified sources of pollution in order to restore and maintain the quality of their water resources (USEPA 1999). TMDLs allow watershed stewards to establish measurable water quality goals based on the difference between site-specific instream conditions and state water quality standards.

A major goal of this TMDL is to achieve meaningful environmental results with regard to the designated uses of the Cape Cod waterbodies. These include water supply, shellfish harvesting, fishing, boating, and swimming. This TMDL establishes the necessary pollutant load to achieve designated uses and water quality standard and the companion document entitled; "*Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts*" provides guidance for the implementation of this TMDL.

Historically, water and sediment quality studies have focused on the control of point sources of pollutants (i.e., discharges from pipes and other structural conveyances) that discharge directly into well-defined hydrologic resources, such as lakes, ponds, or river segments. While this localized approach may be appropriate under certain situations, it typically fails to characterize the more subtle and chronic sources of pollutants that are widely scattered throughout a broad geographic region such as a watershed (e.g., roadway runoff, failing septic systems in high groundwater, areas of concentrated wildfowl use, fertilizers, pesticides, pet waste, and certain agricultural sources). These so called nonpoint sources of pollution often contribute significantly to the decline of water quality through their cumulative impacts. A watershed-level approach that uses the surface drainage area as the basic study unit enables managers to gain a more complete understanding of the potential pollutant sources impacting a waterbody and increases the precision of identifying local

Figure 1-1. Cape Cod Watershed and Pathogen Impaired Segments

problem areas or “hot spots” which may detrimentally affect water and sediment quality. It is within this watershed-level framework that the Massachusetts Department of Environmental Protection (MADEP) commissioned the development of watershed based TMDLs.

1.1. Pathogens and Indicator Bacteria

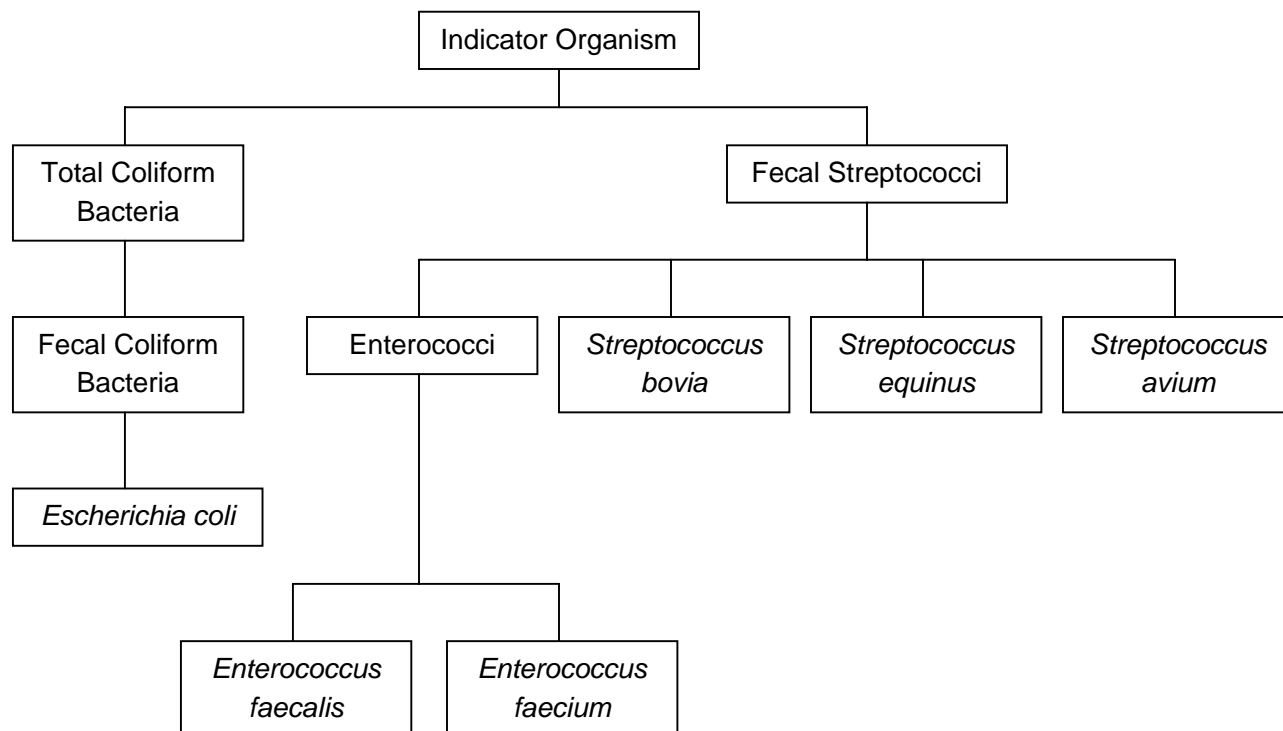
The Cape Cod pathogen TMDL is designed to support reduction of waterborne disease-causing organisms, known as pathogens, to reduce public health risk. Waterborne pathogens enter surface waters from a variety of sources including sewage and the feces of warm-blooded wildlife. These pathogens can pose a risk to human health due to gastrointestinal illness through exposure via ingestion and contact with recreational waters, ingestion of drinking water, and consumption of filter-feeding shellfish.

Waterborne pathogens include a broad range of bacteria and viruses that are difficult to identify and isolate. Thus, specific nonpathogenic bacteria have been identified that are typically associated with harmful pathogens in fecal contamination. These associated nonpathogenic bacteria are used as indicator bacteria as they are easier to identify and measure in the environment. High densities of indicator bacteria increase the likelihood of the presence of pathogenic organisms.

Selection of indicator bacteria is difficult as new technologies challenge current methods of detection and the strength of correlation of indicator bacteria and human illness. Currently, coliform and fecal streptococci bacteria are commonly used as indicators of potential pathogens (i.e., indicator bacteria). Coliform bacteria include total coliforms, fecal coliform and *Escherichia coli* (*E. coli*). Fecal coliform (a subset of total coliform) and *E. coli* (a subset of fecal coliform) bacteria are present in the intestinal tracts of warm blooded animals. Presence of coliform bacteria in water indicates fecal contamination and the possible presence of pathogens. Fecal streptococci bacteria are also used as indicator bacteria, specifically enterococci a subgroup of fecal streptococci. These bacteria also live in the intestinal tract of animals, but their presence is a better predictor of human gastrointestinal illness than fecal coliform since the die-off rate of enterococci is much lower (i.e., enterococci bacteria remain in the environment longer) (USEPA 2001). The relationship of indicator organisms is provided in Figure 1-2. The EPA, in the “*Ambient Water Quality Criteria for Bacteria – 1986*” document, recommends the use of *E. coli* or enterococci as potential pathogen indicators in fresh water and enterococci in marine waters (USEPA 1986).

Massachusetts uses fecal coliform and enterococci as indicator organisms of potential harmful pathogens. The WQS that apply to fresh water are currently based on fecal coliform concentration but will be replaced with *E. coli*. Fecal coliform are also used by the Massachusetts Division of Marine Fisheries (DMF) in their classification of shellfish growing areas. Fecal coliform as the indicator organism for shellfish growing area status is not expected to change at this time. Enterococci are used as the indicator organism for marine beaches, as required by the Beaches Environmental Assessment and Coastal Act of 2000 (BEACH Act), an amendment to the CWA.

Figure 1-2. Relationships among Indicator Organisms (USEPA 2001).



The Cape Cod watershed pathogen TMDLs have been developed using fecal coliform as an indicator bacterium for fresh and marine waters and enterococci for marine beaches. Any changes in the Massachusetts pathogen water quality standard will apply to this TMDL at the time of the standard change. Massachusetts believes that the magnitude of indicator bacteria loading reductions outlined in this TMDL will be both necessary and sufficient to attain present WQS and any future modifications to the WQS for pathogens.

1.2. Comprehensive Watershed-based Approach to TMDL Development

Consistent with Section 303(d) of the CWA, the MADEP has chosen to complete pathogen TMDLs for all waterbodies in the Cape Cod watershed at this time, regardless of current impairment status (i.e., for all waterbody categories in the 2002 List). MADEP believes a comprehensive management approach carried out by all watershed communities is needed to address the ubiquitous nature of pathogen sources present in the Cape Cod watershed. Watershed-wide implementation is needed to meet WQS and restore designated uses in impaired segments while providing protection of desirable water quality in waters that are not currently impaired or not assessed.

As discussed below, this TMDL applies to the 66 pathogen impaired segments of the Cape Cod watershed that are currently listed on the CWA § 303(d) list of impaired waters and determined to be pathogen impaired in the “*Buzzards Bay Watershed 2000 Water Quality Assessment Report*” (MADEP BBWQA; MADEP 2003b) and the “*Cape Cod Water Quality Assessment Report*” (MADEP CCWQA; MADEP 2002a) (see Figure 1, Table 4-3). MADEP recommends however, that the information contained in this TMDL guide management activities for all other waters throughout the watershed to help maintain and protect existing water quality. For these non-impaired waters, Massachusetts is proposing “pollution prevention TMDLs” consistent with CWA § 303(d)(3).

The analyses conducted for the pathogen impaired segments in this TMDL would apply to the non-impaired segments, since the sources and their characteristics are equivalent. The waste load and/or load allocation for each source and designated use would be the same as specified herein. Therefore, the pollution prevention TMDLs would have identical waste load and load allocations based on the sources present and the designated use of the water body segment (see Table ES-1 and Table 6-1).

This Cape Cod watershed TMDL may, in appropriate circumstances, also apply to segments that are listed for pathogen impairment in subsequent Massachusetts CWA § 303(d) Integrated List of Waters. For such segments, this TMDL may apply if, after listing the waters for pathogen impairment and taking into account all relevant comments submitted on the CWA § 303(d) list, the Commonwealth determines with EPA approval of the CWA § 303(d) list that this TMDL should apply to future pathogen impaired segments.

There are 129 waterbody segments assessed by the MADEP in the Cape Cod watershed (MassGIS 2005)¹. These segments consist of 82 estuaries, 67 of which are pathogen impaired and appear as such on the official list of impaired waters. Pathogen TMDLs have been previously prepared and approved for two of these segments – Muddy Creek and Frost Fish Creek. One of the 46 lake segments assessed is pathogen impaired and the single fresh water river segment assessed (Herring River) is not pathogen impaired (Figure 1-1). Pathogen impairment has been documented by the MADEP in previous reports, including the “*Buzzards Bay Watershed 2000 Water Quality Assessment Report*” (MADEP BBWQA; MADEP 2003b) and the “*Cape Cod Water Quality Assessment Report*” (MADEP CCWQA; MADEP 2002a), resulting in the impairment determination. In this TMDL document, an overview of pathogen impairment is provided to illustrate the nature and extent of the pathogen impairment problem. Additional data, not collected by the MADEP or used to determine impairment status, are also provided in this TMDL to illustrate the pathogen problem. Since pathogen impairment has been previously established, only a summary is provided herein.

The watershed based approach applied to complete the Cape Cod watershed pathogen TMDL is straightforward. The approach is focused on identification of sources, source reduction, and implementation of appropriate management plans. Once identified, sources are required to meet

¹ Some segments listed as part of the Buzzards Bay watershed in the 2002 List are located on Cape Cod. This difference stems from basin boundary delineation differences between the 2002 List and the WQS. This report is based on the delineation provided in the WQS. Thirteen segments listed in the 2002 List as part of the Buzzards Bay basin are discussed in this report and are not provided in the “*Pathogen TMDL for the Buzzards Bay Watershed*”.

applicable WQS for indicator bacteria or be eliminated. This approach does not include water quality analysis or other approaches designed to link ambient concentrations with source loadings. For pathogens and indicator bacteria, water quality analyses are generally resource intensive and provide results with large degrees of uncertainty. Rather, this approach focuses on sources and required load reductions, proceeding efficiently toward water quality restoration activities.

The implementation strategy for reducing indicator bacteria is an iterative process where data are gathered on an ongoing basis, sources are identified and eliminated if possible, and control measures including Best Management Practices (BMPs) are implemented, assessed and modified as needed. Measures to abate probable sources of waterborne pathogens include everything from public education, to improved storm water management, to reducing the influence from inadequate and/or failing sanitary sewer infrastructure.

1.3. TMDL Report Format

This document contains the following sections:

- Watershed Description (Section 2) – provides watershed specific information
- Water Quality Standards (Section 3) – provides a summary of current Massachusetts WQS as they relate to indicator bacteria
- Problem Assessment (Section 4) – provides an overview of indicator bacteria measurements collected in the Cape Cod watershed
- Identification of Sources (Section 5) – identifies and discusses potential sources of waterborne pathogens within the Cape Cod watershed
- TMDL Development (Section 6) – specifies required TMDL development components including:
 - Definitions and Equation
 - Loading Capacity
 - Load and Waste Load Allocations
 - Margin of Safety
 - Seasonal Variability
- Implementation Plan (Section 7) – describes specific implementation activities designed to remove pathogen impairment. This section and the companion “*Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts*” document should be used together to support implementing management actions.
- Monitoring Plan (Section 8) – describes recommended monitoring activities
- Reasonable Assurances (Section 9) – describes reasonable assurances the TMDL will be implemented
- Public Participation (Section 10) – describes the public participation process, and
- References (Section 11)

2.0 Watershed Description

Located in southeastern Massachusetts, the Cape Cod watershed includes all or part of 15 communities within 410 square miles. The area lacks main rivers and tributaries characteristic of other watersheds in Massachusetts. In fact, the watershed has very few freshwater streams. The watershed does, however, abound with freshwater lakes and ponds (MADEP 2002a). The area's groundwater supply is the watershed's most important freshwater resource, being the area's primary source of drinking water (EOEA 2004). The groundwater in the Cape Cod Aquifer makes up roughly 96% of available water in Cape Cod. In this watershed, groundwater commonly discharges directly to coastal waters and embayments, unlike other watersheds where groundwater more commonly discharges to fresh surface water. The bordering saltwater bodies, which the river segments discharge, are the Atlantic Ocean, Buzzards Bay, Cape Cod Bay, and Nantucket Sound. Cape Cod has 586 miles of coastline.

Forested area makes up the largest percentage of the land use (40%; Table 2-1; Figure 2-1). Residential areas make up another quarter of the land use (Figure 2-1). Impaired segments and residential areas are concentrated along the shoreline (Figures 2-1).

The Cape Cod drainage area is home to many rare, threatened or endangered species. There are eight Areas of Critical Environmental Concern within the watershed (ACEC; EOEA 2003). "Four towns on Cape Cod are in the "top 10" in Massachusetts for the largest number of state-listed rare species records. The Town of Barnstable is one of only five towns in the state with more than 100 records of rare species" (EOEA 2003).

Several areas on Cape Cod are considered "No Discharge Areas" (NDAs). NDAs are waterbodies in which a state, with EPA approval, has determined to be important ecological or recreational areas worthy of special protection against the release of raw or treated sewage in navigable waters. Vessels are banned from discharging both raw and treated sewage in a NDA. NDAs in Massachusetts are provided in Figure 2-3 (USEPA 2004a).

Being heavily dependent on summer tourism, the area experiences strong seasonal fluctuations in population size (MADEP 2002a). Full time year round population is estimated at 250,000, whereas peak summer population is as high as 500,000 (EOEA 2003).

The waters in the Cape Cod watershed are commonly used for primary and secondary contact recreation (swimming and boating), fishing, wildlife viewing, habitat for aquatic life, irrigation, agricultural uses, industrial cooling, shellfish harvesting, public water supply, and beachfront. Seventy square miles have been designated as a National Park - *Cape Cod National Seashore*, which receives approximately 5 million visitors per year (EOEA 2003). A map illustrating the numerous miles of public and semi-public marine beaches is provided in Figure 2-2.

Table 2-1. Cape Cod Watershed Land Use as of 1999.

Land Use Category	% of Total Watershed Area
Pasture	0.3
Urban Open	1.5
Open Land	7.2
Cropland	0.4
Woody Perennial	0.8
Forest	40.4
Wetland/Salt Wetland	7.0
Water Based Recreation	1.0
Water	4.4
General Undeveloped Land	63.1
Spectator Recreation	<0.1
Participation Recreation	2.2
> 1/2 acre lots Residential	14.9
1/4 - 1/2 acre lots Residential	11.3
< 1/4 acre lots Residential	3.0
Multi-family Residential	0.7
Mining	0.5
Commercial	1.8
Industrial	0.5
Transportation	1.8
Waste Disposal	0.3
General Developed Land	36.9

Figure 2-1. Cape Cod Watershed Land Use as of 1999.

Figure 2-2. Cape Cod Watershed Marine Beach Locations and Pathogen Impaired Segments.

Figure 2-3. General Location of Massachusetts' No Discharge Areas (USEPA 2004a).



3.0 Water Quality Standards

The Surface Water Quality Standards (WQS) for the Commonwealth of Massachusetts establish chemical, physical, and biological standards for the restoration and maintenance of the most sensitive uses (MADEP 2000a). The WQS limit the discharge of pollutants to surface waters for the protection of existing uses and attainment of designated uses in downstream and adjacent segments.

Fecal coliform, enterococci, and *E. coli* bacteria are found in the intestinal tract of warm-blooded animals, soil, water, and certain food and wood processing wastes. “Although they are generally not harmful themselves, they indicate the possible presence of pathogenic (disease-causing) bacteria, viruses, and protozoans that also live in human and animal digestive systems” (USEPA 2004b). These bacteria are often used as indicator bacteria since it is expensive and sometimes difficult to test for the presence of individual pathogenic organisms.

Massachusetts is planning to revise its freshwater WQS by replacing fecal coliform with *E. coli* and enterococci as the regulated indicator bacteria, as recommended by the EPA in the “*Ambient Water Quality Criteria for Bacteria – 1986*” document (USEPA 1986). The state has already done so for public beaches through regulations of the Massachusetts Department of Public Health as discussed below. Currently, Massachusetts uses fecal coliform as the indicator organism for all waters except for marine bathing beaches, where the Federal BEACH Act requires the use of enterococci. Massachusetts anticipates adopting *E. coli* and enterococci for all fresh waters and enterococci for all marine waters, including non bathing marine beaches. Fecal coliform will remain the indicator organism for shellfishing areas, however. The Cape Cod watershed pathogen TMDL has been developed using fecal coliform as the pathogen indicator for fresh and marine waters and enterococci for marine beaches, but the goal of removing pathogen impairment of this TMDL will remain applicable when Massachusetts adopts new indicator bacteria criteria into its WQS. Massachusetts believes that the magnitude of indicator bacteria loading reductions outlined in this TMDL will be both necessary and sufficient to attain present WQS and any future modifications to the WQS for pathogens.

Pathogens can significantly impact humans through ingestion of, and contact with recreational waters, ingestion of drinking water, and consumption of filter-feeding shellfish. In addition to contact recreation, excessive pathogen numbers impact potable water supplies. The amount of treatment (i.e., disinfection) required to produce potable water increases with increased pathogen contamination. Such treatment may cause the generation of disinfection by-products that are also harmful to humans. Further detail on pathogen impacts can be accessed at the following EPA websites:

- Water Quality Criteria: Microbial (Pathogen)
<http://www.epa.gov/ost/humanhealth/microbial/microbial.html>
- Human Health Advisories:
 - Fish and Wildlife Consumption Advisories
<http://www.epa.gov/ebtpages/humaadvisofishandwildlifeconsumption.html>

- Swimming Advisories
<http://www.epa.gov/ebtpages/humaadvisoswimmingadvisories.html>

The Cape Cod watershed contains waterbodies classified as Class A, Class B, Class SA, and Class SB. The corresponding WQS for each class are as follows:

Class A waterbodies - fecal coliform bacteria shall not exceed an arithmetic mean of 20 organisms per 100 mL in any representative set of samples, nor shall 10% of the samples exceed 100 organisms per 100 mL.

Class B and Class SA and SB not designated for shellfishing - the geometric mean of a representative set of fecal coliform samples shall not exceed 200 organisms per 100 mL and no more than 10% of the samples shall exceed 400 organisms per 100 mL. The MADEP may apply these standards on a seasonal basis for waters classified as Class B, and Class SA and SB not designated for shellfishing.

Class SA waters approved for open shellfishing - the geometric mean of a representative set of fecal coliform samples shall not exceed 14 organisms per 100 mL and no more than 10% of the samples shall exceed 43 organisms per 100 mL.

Class SB waters approved for open shellfishing - the geometric mean of a representative set of fecal coliform samples shall not exceed 88 organisms per 100 mL and no more than 10% of the samples shall exceed 260 organisms per 100 mL.

Shellfish areas are classified by the Massachusetts Division of Marine Fisheries (DMF). The classification system is provided below (MassGIS 2005). Figure 1-1 provides designated shellfish growing areas status as of July 1, 2000.

Approved – “Open for harvest of shellfish for direct human consumption subject to local rules and state regulations.” (MassGIS 2005) “The area is shown to be free of bacterial contaminants under a variety of climatological and hydrographical situations (i.e. assumed adverse pollution conditions).” (MADEP 2002a)

Conditionally Approved - "During the time area is approved it is open for harvest of shellfish for direct human consumption subject to local rules and state regulations.” (MassGIS 2005) “This classification category may be assigned for growing areas subject to intermittent and predictable microbiological contamination that may be present due to operation of a sewage treatment plant, rainfall, and/or season.” (MADEP 2002a)

Conditionally Restricted – “During the time area is restricted it is only open for the harvest of shellfish with depuration subject to local rules and state regulations.” (MassGIS 2005) “A classification used to identify a growing area that meets the criteria for the restricted classification except under certain conditions described in a management plan.” (MADEP 2002a)

Restricted – “Open for harvest of shellfish with depuration subject to local rules and state regulations or for the relay of shellfish.” (MassGIS 2005) “A classification used to identify where harvesting shall be by special license and the shellstock, following harvest, is subject to a suitable and effective treatment process through relaying or depuration. Restricted growing areas are mildly or moderately contaminated only with bacteria.” (MADEP 2002a)

Management Closure – “Closed for the harvest of shellfish. Not enough testing has been done in the area to determine whether it is fit for shellfish harvest or not.” (MADEP 2002a)

Prohibited – “Closed for harvest of shellfish.” (MassGIS 2005) “A classification used to identify a growing area where the harvest of shellstock is not permitted. Growing area waters are so badly contaminated that no reasonable amount of treatment will make the shellfish safe for human consumption. Growing areas must also be classified as Prohibited if there is no or insufficient information available to make a classification decision.” (MADEP 2002a)

In general, shellfish harvesting use is supported (i.e., non-impaired) when shellfish harvested from approved open shellfish areas are suitable for consumption without depuration and shellfish harvested from restricted shellfish areas are suitable for consumption with depuration. For an expanded discussion on the relationship between the DMF shellfish growing areas classification and the MADEP designated use support status, please see the “*Buzzards Bay Watershed 2000 Water Quality Assessment Report*” (MADEP BBWQA; MADEP 2003b) and the “*Cape Cod Water Quality Assessment Report*” (MADEP CCWQA; MADEP 2002a).

In addition to the WQS, the Commonwealth of Massachusetts Department of Public Health (MADPH) has established minimum standards for bathing beaches (105 CMR 445.000) under the State Sanitary Code, Chapter VII (www.mass.gov/dph/dcs/bb4_01.pdf). These standards will soon be adopted by the MADEP as state surface WQS for fresh water and these standards will subsequently apply to this TMDL. The MADPH bathing beach standards are generally the same as those which were recommended in the “*Ambient Water Quality Criteria for Bacteria – 1986*” document published by the EPA (USEPA 1986). In the above referenced document, the EPA recommended the use of enterococci as the indicator bacterium for marine recreational waters and enterococci or *E. coli* for fresh waters. As such, the following MADPH standards have been established for bathing beaches in Massachusetts:

Marine Waters - (1) No single enterococci sample shall exceed 104 colonies per 100 mL and the geometric mean of the most recent five enterococci levels within the same bathing season shall not exceed 35 colonies per 100 mL.

Freshwaters - (1) No single *E. coli* sample shall exceed 235 colonies per 100 mL and the geometric mean of the most recent five *E. coli* samples within the same bathing season shall not exceed 126 colonies per 100 mL; or (2) No single enterococci sample shall exceed 61 colonies per 100 mL and the geometric mean of the most recent five enterococci samples within the same bathing season shall not exceed 33 colonies per 100 mL.

The Federal BEACH Act of 2000 established a Federal standard for marine beaches. These standards are essentially the same as the MADPH marine beach standard (i.e., single sample not to exceed 104 cfu/100mL and geometric mean of a statistically sufficient number of samples not to exceed 35 cfu/100mL). The Federal BEACH Act and MADPH standards can be accessed on the worldwide web at <http://www.epa.gov/waterscience/beaches/act.html> and www.mass.gov/dph/dcs/bb4_01.pdf, respectively.

Figure 2-2 provides the location of marine bathing beaches, where the MADPH Marine Waters and the Federal BEACH Act standards would apply. A map of freshwater beaches is not available at this time. However, a list of beaches (fresh and marine) by community with indicator bacteria data can be found in the annual reports on the testing of public and semi-public beaches provided by the MADPH. These reports are available for download from the MADPH website located at <http://www.mass.gov/dph/beha/tox/reports/beach/beaches.htm>.

4.0 Problem Assessment

Pathogen impairment has been documented at numerous locations throughout the Cape Cod watershed, as shown in Figure 1-1. Excessive concentrations of indicator bacteria (e.g., fecal coliform, enterococci, *E. coli* etc.) can indicate the presence of sewage contamination and possible presence of pathogenic organisms. The amount of indicator bacteria and potential pathogens entering waterbodies is dependent on several factors including watershed characteristics and meteorological conditions. Indicator bacteria levels generally increase with increasing development activities, including increased impervious cover, illicit sewer connections, and failed septic systems.

Indicator bacteria levels also tend to increase with wet weather conditions as storm sewer systems overflow and/or storm water runoff carries fecal matter that has accumulated to the river via overland flow and storm water conduits. In some cases, dry weather bacteria concentrations can be higher when there is a constant source that becomes diluted during periods of precipitation, such as with illicit connections. The magnitude of these relationships is variable, however, and can be substantially different temporally and spatially throughout the United States or within each watershed.

Tables 4-1 and 4-2 provide ranges of fecal coliform concentrations in storm water associated with various land use types. Pristine areas are observed to have low indicator bacteria levels and residential areas are observed to have elevated indicator bacteria levels. Development activity generally leads to decreased water quality (e.g., pathogen impairment) in a watershed. Development-related watershed modification includes increased impervious surface area which can (USEPA 1997):

- Increase flow volume,
- Increase peak flow,
- Increase peak flow duration,
- Increase stream temperature,
- Decrease base flow, and
- Change sediment loading rates

Many of the impacts associated with increased impervious surface area also result in changes in pathogen loading (e.g., increased sediment loading can result in increased pathogen loading). In addition to increased impervious surface impacts, increased human and pet densities in developed areas increase potential fecal contamination. Furthermore, storm water drainage systems and associated storm water culverts and outfall pipes often result in the channelization of streams which leads to less attenuation of pathogen pollution.

Table 4-1 Wachusett Reservoir Storm Water Sampling (as reported in MADEP 2002b) original data provided in MDC Wachusett Storm Water Study (June 1997).

Land Use Category	Fecal Coliform Bacteria¹ Organisms / 100 mL
Agriculture, Storm 1	110 - 21,200
Agriculture, Storm 2	200 - 56,400
"Pristine" (not developed, forest), Storm 1	0 - 51
"Pristine" (not developed, forest), Storm 2	8 - 766
High Density Residential (not sewered, on septic systems), Storm 1	30 - 29,600
High Density Residential (not sewered, on septic systems), Storm 2	430 - 122,000

¹ Grab samples collected for four storms between September 15, 1999 and June 7, 2000

Table 4-2. Lower Charles River Basin Storm Water Event Mean Bacteria Concentrations (data summarized from USGS 2002).¹

Land Use Category	Fecal Coliform (CFU/100 mL)	Enterococcus Bacteria (CFU/100 mL)	Number of Events
Single Family Residential	2,800 – 94,000	5,500 – 87,000	8
Multifamily Residential	2,200 – 31,000	3,200 – 49,000	8
Commercial	680 – 28,000	2,100 – 35,000	8

¹ An Event Mean Concentration (EMC) is the concentration of a flow proportioned sample throughout a storm event. These samples are commonly collected using an automated sampler which can proportion sample aliquots based on flow.

Pathogen impaired estuary segments represent 70.0% of the total estuary area assessed (30.7 square miles of 43.8 to square miles assessed; includes areas associated with the two estuaries with existing pathogen TMDLs). Pathogen impaired lake segments represent less than 1% of the total lake area assessed (4.4 acres of 5058.7 total acres assessed). In total, 66 segments requiring TMDLs contain indicator bacteria concentrations in excess of the Massachusetts WQS for Class A, SA, B, or SB waterbodies (314 CMR 4.05)¹, the MADPH standard for bathing beaches², and/or the BEACH Act³. The basis for impairment listings is provided in the *2002 List* (MADEP 2003a). Data presented in the Buzzards Bay Water Quality Assessment (BBWQA), Cape Cod Water Quality Assessment (CCWQA) and other data collected by the MADEP were used to generate the *2002 List*.

A list of pathogen impaired segments requiring TMDLs is provided in Table 4-3. Additional details regarding each impaired segment including water withdrawals, discharges, use assessments and recommendations to meet use criteria are provided in the MADEP WQA. This TMDL does not, however, apply to Muddy Creek (MA96-51) or Frost Fish Creek (MA96-49), as pathogen TMDLs for these segments have been previously developed.

An overview of the Cape Cod watershed pathogen impairment is provided in this section to illustrate the nature and extent of the impairment. Since pathogen impairment has been previously established and documented on the *2002 List*, it is not necessary to provide detailed documentation of pathogen impairment herein. Data from the MADEP BBWQA, CCWQA and Massachusetts Office of Coastal Zone Management (MACZM) were reviewed and are summarized by segment below for illustrative purposes.

¹ Class A: Fecal coliform bacteria shall not exceed an arithmetic mean of 20 organisms per 100 mL in any representative set of samples, nor shall 10% of the samples exceed 100 organisms per 100 mL.

Class SA (Shellfishing approved): Fecal coliform bacteria shall not exceed an arithmetic mean of 14 organisms per 100 mL in any representative set of samples, nor shall 10% of the samples exceed 43 organisms per 100 mL.

Class SB (Shellfishing approved): Fecal coliform bacteria shall not exceed an arithmetic mean of 88 organisms per 100 mL in any representative set of samples, nor shall 10% of the samples exceed 260 organisms per 100 mL.

Class B, Class SA & Class SB (waters not designated for shellfishing): Fecal coliform bacteria shall not exceed a geometric mean of 200 organisms per 100 mL in any representative set of samples, nor shall 10% of the samples exceed 400 organisms per 100 mL. The MADEP may apply these standards on a seasonal basis.

² Freshwater bathing beaches: No single *E. coli* sample shall exceed 235 colonies per 100 mL and the geometric mean of the most recent five *E. coli* samples within the same bathing season shall not exceed 126 colonies per 100 mL; or No single enterococci sample shall exceed 61 colonies per 100 mL and the geometric mean of the most recent five (5) enterococci samples within the same bathing season shall not exceed 33 colonies per 100 mL.

Marine bathing beaches: No single enterococci sample shall exceed 104 colonies per 100 mL and the geometric mean of the most recent five enterococci levels within the same bathing season shall not exceed 35 colonies per 100 mL.

³ BEACH Act - Marine bathing beaches: No single enterococci sample shall exceed 104 colonies per 100 mL and the geometric mean of the most recent five enterococci levels within the same bathing season shall not exceed 35 colonies per 100 mL.

Table 4-3. Cape Cod Pathogen Impaired Segments Requiring TMDLs (adapted from MADEP 2003b, MADEP 2002a and MassGIS 2005).

Segment ID	Segment Name	Segment Size ¹	Segment Description
MA96-01	Barnstable Harbor	2.56	From the mouths of Scorton and Spring Creeks east to an imaginary line drawn from Beach Point to the western edge of Mill Creek estuary, Barnstable.
MA96-02	Bumps River	0.1	From the outlet of a pond at Bumps River Rd. through Scudder Bay to South Main St. bridge (confluence with Centerville River), Barnstable.
MA96-04	Centerville River	0.3	From headwaters in wetland west of Strawberry Hill Rd. to confluence with Centerville Harbor, including East Bay, Barnstable.
MA96-05	Hyannis Harbor	0.47	The waters from the shoreline to an imaginary line drawn from the light at the end of Hyannis breakwater to the point west of Dunbars Point, Barnstable.
MA96-06	Maraspin Creek	0.03	From headwaters just south of Rte. 6A to confluence with Barnstable Harbor at Blish Point, Barnstable.
MA96-07	Prince Cove	0.1	Includes adjacent unnamed cove to mouth at Fox Island, Barnstable.
MA96-08	Shoestring Bay	0.4	Quinaquisset Ave. to Ryefield Point, Barnstable/Mashpee.
MA96-09	Quivett Creek	0.02	Outlet of unnamed pond just south of Rte. 6A to the mouth at Cape Cod Bay, Brewster/Dennis.
MA96-11	Stage Harbor	0.86	The waters including Mitchell R. from Mill Pond to Sears Point and Harding Beach Point, Chatham.
MA96-12	Bass River	0.90	Rte. 6 to mouth at Nantucket Sound, Dennis/Yarmouth.
MA96-13	Sesuit Creek	0.06	From Rte. 6A to mouth at Cape Cod Bay, Dennis.
MA96-14	Swan Pond River	0.06	Outlet of Swan Pond to confluence with Nantucket Sound, Dennis.
MA96-15	Boat Meadow River	0.09	Headwaters east of old Railway Grade to mouth at Cape Cod Bay, Eastham.
MA96-16	Rock Harbor Creek	0.04	Outlet Cedar Pond to mouth at Cape Cod Bay, Eastham/Orleans.
MA96-17	Falmouth Inner Harbor	0.07	Waters included north of Inner Falmouth Harbor Light, Falmouth.
MA96-18	Great Harbor	0.35	The waters north of an imaginary line drawn southeast from Devils Foot to Juniper Point, Falmouth.
MA96-19	Little Harbor	0.05	The waters north of an imaginary line drawn from Juniper Point east to Nobska beach, Falmouth.
MA96-20	Quashnet River	0.1	Just south of Rte. 28 to mouth at Waquoit Bay, Falmouth (also known as Moonakis R.).
MA96-21	Waquoit Bay	1.54	From mouths of Seapit R., Quashnet R., Little R., and Great R. to confluence with Vineyard Sound, Falmouth.
MA96-22	Herring River	0.1	Outlet of Reservoir northwest of Bells Neck Rd. to mouth at Nantucket Sound, Harwich.
MA96-23	Saquatucket Harbor	0.02	South of Rte. 28 to confluence with Nantucket Sound, Harwich.
MA96-24	Mashpee River	0.1	Quinaquisset Ave. to mouth at Popponesset Bay, Mashpee.
MA96-26	Little Namskaket Creek	0.02	Source to mouth at Cape Cod Bay.
MA96-27	Namskaket Creek	0.01	From outlet of unnamed pond north of Rte. 6A in Orleans to mouth at Cape Cod Bay, Brewster/Orleans.

Table 4-3 (continued). Cape Cod Pathogen Impaired Segments Requiring TMDLs (adapted from MADEP 2003b, MADEP 2002a and MassGIS 2005).

Segment ID	Segment Name	Segment Size ¹	Segment Description
MA96-29	Provincetown Harbor	3.82	The waters northwest of an imaginary line drawn from the tip of Long Point to Beach Point Beach, Provincetown.
MA96-30	Scorton Creek	0.05	Jones Lane to mouth at Cape Cod Bay, Sandwich.
MA96-31	Pamet River	0.2	Rte. 6 to mouth at Cape Cod Bay (Including Pamet Harbor), Truro.
MA96-32	Duck Creek	0.1	From Cannon Hill to Shirttail Point, Wellfleet.
MA96-33	Herring River	0.7	Griffin Island to Wellfleet Harbor, Wellfleet.
MA96-34	Wellfleet Harbor	7.27	The waters north of an imaginary line drawn west from Jersey Point to Sunken Meadow, excluding the estuaries of Herring River, Duck Creek, and Blackfish Creek, Wellfleet.
MA96-35	Chase Garden Creek	0.2	Source west of Rte. 6A, Dennis to mouth at Cape Cod Bay, Dennis/Yarmouth.
MA96-36	Lewis Bay	1.35	Includes Pine Island Creek and Uncle Roberts Cove to confluence with Nantucket Sound, Yarmouth.
MA96-37	Mill Creek	0.09	From Keveny/Mill Lane north to confluence with Cape Cod Bay Barnstable/Yarmouth.
MA96-38	Parkers River	0.05	Outlet Seine Pond to mouth at Nantucket Sound, Yarmouth.
MA96-39	Popponesset Creek	NA	NA
MA96-41	Mill Creek	NA	NA
MA96-42	Taylors Pond	NA	NA
MA96-43	Harding Beach Pond	NA	NA
MA96-44	Bucks Creek	NA	NA
MA96-45	Oyster Pond	NA	NA
MA96-46	Oyster Pond River	NA	NA
MA96-50	Ryders Cove	NA	NA
MA96-53	Perch Pond	NA	NA
MA96-54	Great Pond	NA	NA
MA96-55	Great Pond	NA	NA
MA96-57	Bournes Pond	NA	NA
MA96-58	Hamblin Pond	NA	NA
MA96-61	Little River	NA	NA
MA96-62	Oyster Pond	NA	NA
MA96-63	Cotuit Bay	NA	NA
MA96-64	Seapuit River	NA	NA
MA96-66	North Bay	NA	NA
MA96257	Red Lily Pond	4.4	Barnstable.
MA95-14	Cape Cod Canal	1.13	Connection between Buzzards Bay and Cape Cod Bay in Bourne and Sandwich.
MA95-48	Eel Pond	0.03	Salt water pond that discharges to Back River, Bourne.
MA95-47	Back River	0.08	Outlet of small unnamed pond, downstream from Mill Pond, Bourne to confluence with Phinneys Harbor, Bourne (excluding Eel Pond).
MA95-15	Phinneys Harbor	0.73	From the confluence with Back R. to its mouth at Buzzards Bay between Mashpee and Tobys Islands, Bourne.

Table 4-3 (continued). Cape Cod Pathogen Impaired Segments Requiring TMDLs (adapted from MADEP 2003b, MADEP 2002a and MassGIS 2005).

Segment ID	Segment Name	Segment Size ¹	Segment Description
MA95-16	Pocasset River	0.05	From the outlet of Mill Pond, Bourne to the mouth at Buzzards Bay, Bourne.
MA95-17	Pocasset Harbor	0.33	From the confluence with Red Brook Harbor near the northern portion of Bassett's Island and Patuisset to the mouth at Buzzards Bay between Bassett's Island and Wings Neck, Bourne.
MA95-18	Red Brook Harbor	0.91	From the confluence with Pocasset Harbor between the northern portion of Bassett's Island and Patuisset to its mouth at Buzzards Bay between Bassett's island and Scraggy Neck, Bourne (including Hen Cove).
MA95-21	Herring Brook	0.01	From its headwaters, northeast of Dale Dr. and west of Rte. 28A, to its mouth at Buzzards Bay, Falmouth.
MA95-46	Harbor Head	0.02	The semi-enclosed body of water south of the confluence with West Falmouth Harbor at Chappaquoit Rd., Falmouth.
MA95-22	West Falmouth Harbor	0.29	From the confluence with Harbor Head at Chappaquoit Rd., Falmouth to the mouth at Buzzards Bay at a line connecting the ends of the seawalls from Little Island and Chappaquoit Point, Falmouth (including Snug Harbor).
MA95-23	Great Sippewisset Creek	0.03	From the outlet of Beach Pond in Great Sippewisset marsh to the mouth at Buzzards Bay, Falmouth, including the unnamed tributary from the outlet of Fresh Pond, and Quahog Pond, Falmouth.
MA95-24	Little Sippewisset Marsh	0.02	From the headwaters north of Sippewisset Rd., Falmouth to the mouth at Buzzards Bay near Saconneset Hills, Falmouth.
MA95-25	Quissett Harbor	0.17	The semi-enclosed body of water landward of a line drawn between The Knob and Gansett Point, Falmouth.

¹ Units = Miles for river segments and square miles for estuaries

This TMDL was based on the current WQS using fecal coliform as an indicator organism for fresh and marine waters and enterococci for marine beaches. Enterococci data are provided at the bottom of each table when data are available. The MADEP is in the process of developing new WQS incorporating *E. coli* and enterococci as indicator organisms for all waters other than shellfishing and potable water intake areas. Not all data presented herein were used to determine impairment listing due to a variety of reasons (including data quality assurance and quality control). The MADEP used only a subset of the available data to generate the 2002 List. Other data presented in this section are for illustrative purposes only.

Data from the Massachusetts Division of Marine Fisheries (DMF) were used, in part, as the basis for pathogen impairment for many of the estuarine areas (Figure 1-1). "Each year water samples are collected by the DMF at 2,320 stations in 294 growing areas in Massachusetts's coastal waters at a minimum frequency of five times while open to harvesting" (DMF 2002). Due to the volume of data collected by the DMF, the complete range of results is not provided herein, but a small subset may be provided. For the most recent indicator bacteria sampling data, please contact your local city or town shellfish constable or DMF's Shellfish Project.

Data summarized in the following subsections can be found at:

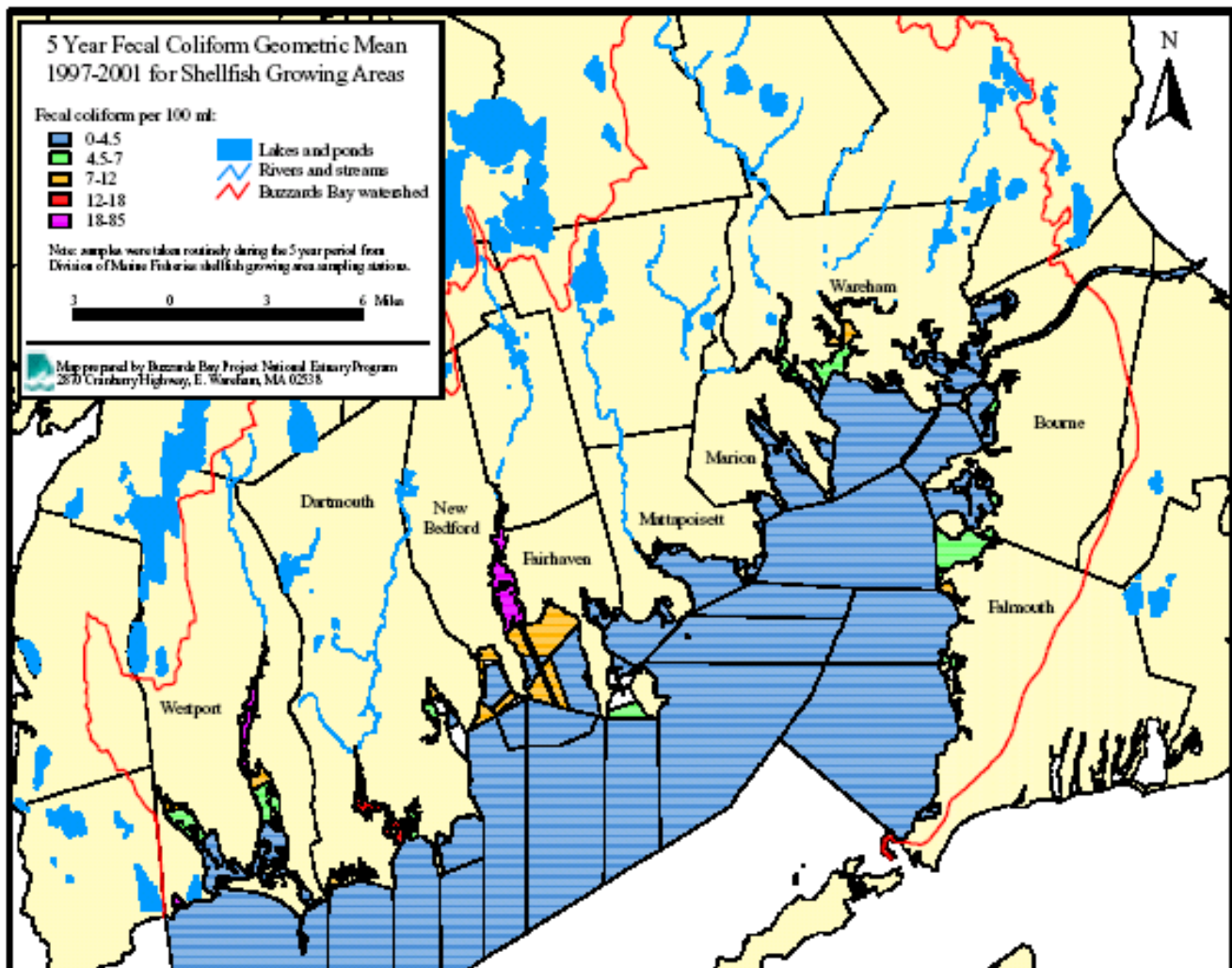
- **MADEP CCWQA** – Cape Cod Watershed Water Quality Assessment Report available for download at <http://www.mass.gov/dep/brp/wm/wqassess.htm>.
- **MADEP BBWQA** – Buzzards Bay Watershed 2000 Water Quality Assessment Report available for download at <http://www.mass.gov/dep/brp/wm/wqassess.htm>.

The MADPH publishes annual reports on the testing of public and semi-public beaches for both marine and fresh waters. These documents provide water quality data for each bathing beach by community and note if there were exceedances of water quality criteria. There is also a list of communities that did not report testing results. These reports can be downloaded from <http://www.mass.gov/dph/beha/tox/reports/beach/beaches.htm>. Marine and freshwater beach status is highly variable and is therefore not provided in each segment description. Please see the MADPH annual beach report for specific details regarding swimming beaches.

The purpose of this section of the report is to briefly describe the impaired waterbody segments in the Cape Cod watershed. For more information on any of these segments, see the "*Cape Cod Watershed Water Quality Assessment Report*" on the MADEP website: <http://www.mass.gov/dep/brp/wm/wqassess.htm>

The eastern shore of Buzzards Bay south of Cape Cod Canal is included as part of the Cape Cod watershed. Between 1997 and 2001, DMF collected over 37,000 fecal coliform samples from tributaries of Buzzards Bay. The geometric means for shellfish growing areas over the same period is given in Figure 4-1.

Figure 4-1. DMF Fecal Coliform Five Year Geometric Mean (1997-2001; MACZM 2003).



Tens of thousands of additional samples have been collected throughout the Cape Cod watershed by DMF. DMF has a well-established and effective shellfish monitoring program that provides quality assured data for each shellfish growing area. In addition, each growing area must have a complete sanitary survey every 12 years, a triennial evaluation every three years and an annual review in order to maintain a shellfishing harvesting classification with the exception of those areas already classified as Prohibited. The National Shellfish Sanitation Program establishes minimum requirements for sanitary surveys, triennial evaluations, annual reviews and annual fecal coliform water quality monitoring and includes identification of specific sources and assessment of effectiveness of controls and attainment of standards.

Barnstable Harbor Segment MA96-01

This 2.56 square mile (mi²) Class SA, Outstanding Resource Water (ORW) segment extends from the mouths of Scorton and Spring Creeks to Beach Point and the western edge of the Mill Creek estuary in Barnstable. The Barnstable Harbor recharge area contains 107.4 acres of cranberry bog open space. A conservative estimate of water use by this bog area is 0.96 million gallons per day (mgd). The Barnstable Fire District, Yarmouth Fire Department, Iyanough Hills Golf Course, and Cummaquid Golf Club all have permits to withdraw water from this segment. A complete listing of water withdrawal permits is provided in Appendix C, Table C2 in the CCWQA (MADEP 2002a). There are no regulated wastewater dischargers in this segment. However the Town of Barnstable is in the process of applying for a National Pollutant Discharge Elimination System (NPDES) permit for the municipal separate storm sewer system (MS4).

DMF Designated Shellfish Growing Areas Status: Approved for 2.08 mi²; Conditional Approved for 0.47 mi²; Prohibited for 0.01 mi² (Figure 1-1).

The DMF collected dry weather fecal coliform samples at eight stations along this segment between March 1996 and August 2001. A total of 280 samples were collected. Fecal coliform values ranged from 1.9 to 63 colony forming units (cfu) per 100mL.

Bumps River Segment MA96-02

This 0.1 mi² Class SA segment extends from the outlet of a pond at Bumps River Road to the South Main Street bridge in Barnstable. The Bumps River recharge area contains 53.6 acres of cranberry bog open space. A conservative estimate of water use by this bog area is 0.48 mgd. The Centerville-Osterville Water Department has a permit to withdraw water from this segment. A complete listing of water withdrawal permits is provided in Appendix C, Table C2 in the CCWQA (MADEP 2002a). There are no regulated wastewater dischargers in this segment. However the Town of Barnstable is in the process of applying for a NPDES permit for the MS4.

DMF Designated Shellfish Growing Areas Status: Restricted for 0.03 mi²; Prohibited for 0.07 mi² (Figure 1-1).

The DMF collected dry weather fecal coliform samples at four stations along this segment between November 1996 and August 2001. A total of 77 samples were collected. Fecal coliform values ranged from 1.9 to 312 cfu/100mL.

Centerville River Segment MA96-04

This 0.3 mi² Class SA segment extends from its headwaters in a wetland west of Strawberry Hill Road to its confluence with Centerville Harbor. The Centerville River recharge area contains 61.03 acres of cranberry bog open space. A conservative estimate of water use by this bog area is 0.55 mgd. The Bumps River recharge area is included in the Centerville River recharge area; therefore the Centerville-Osterville Water Department's permit to withdraw water from Bumps River may impact this segment. A complete listing of water withdrawal permits is provided in Appendix C, Table C2 in the CCWQA (MADEP 2002a). There are no regulated wastewater dischargers in this segment. However, the Town of Barnstable is in the process of applying for a NPDES permit for the MS4.

DMF Designated Shellfish Growing Areas Status: Restricted for 0.22 mi²; Prohibited for 0.08 mi² (Figure 1-1).

The DMF collected dry weather fecal coliform samples at eight stations along this segment between May 1996 and August 2001. A total of 183 samples were collected. Fecal coliform values ranged from 1.9 to 312 cfu/100mL.

Hyannis Harbor Segment MA96-05

This 0.47 mi² Class SA segment is bounded by a line drawn from the light at the end of Hyannis breakwater to the point west of Dunbar's Point. The recharge area for this segment has not been defined; therefore, the number of acres devoted to cranberry bogs has not been determined. Sheraton Hyannis Resort Twin Brooks has a golf course water withdrawal well along this segment. A complete listing of water withdrawal permits is provided in Appendix C, Table C2 in the CCWQA (MADEP 2002a). There are no regulated wastewater dischargers in this segment. However the Town of Barnstable is in the process of applying for a NPDES permit for the MS4.

DMF Designated Shellfish Growing Areas Status: Approved for 0.38 mi²; Conditionally Approved for 0.09 mi² (Figure 1-1).

The DMF collected dry weather fecal coliform samples at five stations along this segment between March 1996 and September 2001. A total of 146 samples were collected. Fecal coliform values ranged from 1.9 to 51 cfu/100mL.

Maraspin Creek Segment MA96-06

This 0.03 mi² Class SA segment extends from its headwaters south of Rte. 6A to its confluence with Barnstable Harbor. Maraspin Creek's recharge area is a portion of Barnstable Harbor's recharge area. The withdrawals listed under Barnstable Harbor may also impact this segment. A complete listing of water withdrawal permits is provided in Appendix C, Table C2 in the CCWQA (MADEP 2002a). There are no regulated wastewater dischargers in this segment. However the Town of Barnstable is in the process of applying for a NPDES permit for the MS4.

DMF Designated Shellfish Growing Areas Status: Prohibited (Figure 1-1).

Prince Cove Segment MA96-07

This 0.1 mi² Class SA segment includes Prince Cove and another unnamed cove and extends to the mouth at Fox Island in Barnstable. The Prince Cove recharge area contains 237.64 acres of cranberry bog open space. A conservative estimate of water use by this bog area is 2.12 mgd. The following are permitted to withdraw water from this segment: Centerville-Osterville Water Department, Sandwich Water District, The Ridge Club, and Barnstable Municipal Golf Course. A complete listing of water withdrawal permits is provided in Appendix C, Table C2 in the CCWQA (MADEP 2002a). There are no regulated wastewater dischargers in this segment. However the Town of Barnstable is in the process of applying for a NPDES permit for the MS4.

DMF Designated Shellfish Growing Areas Status: Conditionally Approved (Figure 1-1).

The DMF collected dry weather fecal coliform samples at five stations along this segment between January 1996 and April 2001. A total of 165 samples were collected. Fecal coliform values ranged from 1.9 to 51 cfu/100mL. Using DNA, a study showed that 43% of the pollutants in the northern section of Prince Cove were caused by human waste (EOEA 2003).

Shoestring Bay Segment MA96-08

This 0.4 mi² Class SA segment extends from Quinacisset Avenue to Ryefield Point in Barnstable/Mashpee. The Shoestring Bay recharge area contains 99.15 acres of cranberry bog open space. A conservative estimate of water use by this bog area is 0.89 mgd. The following are permitted to withdraw water from this segment: Cotuit Water Department, Mashpee Water District, and Willowbend Development Corporation. A complete listing of water withdrawal permits is provided in Appendix C, Table C2 in the CCWQA (MADEP 2002a). There are no regulated wastewater dischargers in this segment. However the Towns of Barnstable and Mashpee are in the process of applying for a NPDES permit for the MS4.

DMF Designated Shellfish Growing Areas Status: Prohibited (Figure 1-1).

The DMF collected dry weather fecal coliform samples at six stations along this segment between March 1996 and March 2001. A total of 100 samples were collected. Fecal coliform values ranged from 1.9 to 51 cfu/100mL.

Quivett Creek Segment MA96-09

This 0.02 mi² Class SA segment extends from the outlet of an unnamed pond south of Route 6A to the mouth at Cape Cod Bay in Brewster/Dennis. There are no water withdrawals or dischargers in this segment. However, the Town of Dennis is in the process of applying for a NPDES permit for the MS4.

DMF Designated Shellfish Growing Areas Status: Prohibited (Figure 1-1).

Stage Harbor Segment MA96-11

This 0.86 mi² Class SA segment includes Mitchell River from Mill Pond to Sears Point and Harding Beach Point in Chatham. There are no water withdrawals or dischargers in this segment.

DMF Designated Shellfish Growing Areas Status: Approved for 0.85 mi²; Conditionally Approved for 0.01 mi² (Figure 1-1).

The DMF collected dry weather fecal coliform samples at six stations along this segment between January 1996 and September 2001. A total of 169 samples were collected. Fecal coliform values ranged from 1.9 to 50 cfu/100mL.

Bass River Segment MA96-12

This 0.90 mi² Class SA segment extends from Route 6 to the mouth at Nantucket Sound in Dennis/Yarmouth. The following are permitted to withdraw water from this segment: Dennis Water District, Yarmouth Water Department, Davenport Realty Blue Rock G.C., and Bass River Golf Course. A complete listing of water withdrawal permits is provided in Appendix C, Table C2 in the CCWQA (MADEP 2002a). There are no regulated wastewater dischargers in this segment. However the Towns of Dennis and Yarmouth are in the process of applying for a NPDES permit for the MS4.

DMF Designated Shellfish Growing Areas Status: Conditionally Approved for 0.89 mi²; Prohibited for 0.01 mi² (Figure 1-1).

The DMF collected dry weather fecal coliform samples at nine stations along this segment between January 1996 and May 2001. A total of 306 samples were collected. Fecal coliform values ranged from 1.9 to 50 cfu/100mL.

Sesuit Creek Segment MA96-13

This 0.06 mi² Class SA segment extends from Route 6A to its mouth at Cape Cod Bay in Dennis. The following are permitted to withdraw water from this segment: Dennis Water District, Dennis Pines Golf Course, and Dennis Highlands Golf Course. A complete listing of water withdrawal permits is provided in Appendix C, Table C2 in the CCWQA (MADEP 2002a). There are no regulated wastewater dischargers in this segment. However the Town of Dennis is in the process of applying for a NPDES permit for the MS4.

DMF Designated Shellfish Growing Areas Status: Conditionally Approved (Figure 1-1).

The DMF collected dry weather fecal coliform samples at four stations along this segment between January 1996 and May 2001. A total of 90 samples were collected. Fecal coliform values ranged from 1.9 to 50 cfu/100mL.

Swan Pond River Segment MA96-14

This 0.06 mi² Class SA segment extends from the outlet of Swan Pond to the river's confluence with Nantucket Sound in Dennis. The Swan Pond River recharge area contains 22.34 acres of cranberry bog open space. A conservative estimate of water use by this bog area is 0.20 mgd. Dennis Water District has a permit to withdraw water from this segment. A complete listing of water withdrawal permits is provided in Appendix C, Table C2 in the CCWQA (MADEP 2002a). There are no

regulated wastewater dischargers in this segment. However the Town of Dennis is in the process of applying for a NPDES permit for the MS4.

DMF Designated Shellfish Growing Areas Status: Prohibited (Figure 1-1).

The DMF collected dry weather fecal coliform samples at five stations along this segment between February 1996 and February 2000. A total of 100 samples were collected. Fecal coliform values ranged from 1.8 to 51 cfu/100mL.

Boat Meadow River Segment MA96-15

This 0.09 mi² Class SA, ORW segment extends from the river's headwaters east of old Railway Grade to the river's mouth at Cape Cod Bay in Eastham. There are no regulated withdrawals or NPDES regulated discharges in this segment.

DMF Designated Shellfish Growing Areas Status: Prohibited (Figure 1-1).

The DMF collected dry weather fecal coliform samples at four stations along this segment between April 1997 and February 1998. A total of 11 samples were collected. Fecal coliform values ranged from 1.9 to 51 cfu/100mL.

Rock Harbor Creek Segment MA96-16

This 0.04 mi² Class SA, ORW segment extends from the outlet of Cedar Pond to the creek's mouth at Cape Cod Bay in Eastham/Orleans. There are no regulated withdrawals or NPDES regulated discharges in this segment.

DMF Designated Shellfish Growing Areas Status: Approved for 0.01 mi²; Prohibited for 0.03 mi² (Figure 1-1).

The DMF collected dry weather fecal coliform samples at three stations along this segment between September 1997 and May 1998. A total of 12 samples were collected. Fecal coliform values ranged from 1.9 to 51 cfu/100mL.

Falmouth Inner Harbor Segment MA96-17

This 0.07 mi² Class SB segment includes the waters north of Inner Falmouth Harbor Light in Falmouth. There are no regulated withdrawals or NPDES regulated discharges in this segment.

DMF Designated Shellfish Growing Areas Status: Approved (Figure 1-1).

Great Harbor Segment MA96-18

This 0.35 mi² Class SA segment includes the waters north of a line drawn from Devils Foot to Juniper Point in Falmouth. There are no regulated withdrawals or NPDES regulated discharges in this segment.

DMF Designated Shellfish Growing Areas Status: Approved for 0.03 mi²; Prohibited for 0.05 mi² (Figure 1-1).

The DMF collected dry weather fecal coliform samples at six stations along this segment between March 1996 and September 2001. A total of 115 samples were collected. Fecal coliform values ranged from 1.9 to 51 cfu/100mL.

Little Harbor Segment MA96-19

This 0.05 mi² Class SA segment includes the waters north of a line drawn from Juniper Point to Nobska beach in Falmouth. There are no regulated withdrawals or NPDES regulated discharges in this segment.

DMF Designated Shellfish Growing Areas Status: Approved for 0.02 mi²; Conditionally Approved for 0.02 mi²; Prohibited for 0.01 mi² (Figure 1-1).

The DMF collected dry weather fecal coliform samples at four stations along this segment between January 1996 and August 2001. A total of 133 samples were collected. Fecal coliform values ranged from 1.9 to 51 cfu/100mL.

Quashnet River Segment MA96-20

This 0.1 mi² Class SA river segment extends from just south of Route 28 to its mouth at Waquoit Bay in Falmouth. This segment is also known as the Moonakis River. The recharge area contains 62.75 acres of cranberry bog open space. A conservative estimate of water use by this bog area is 0.56 mgd. The following are permitted to withdraw water from this segment: Sandwich Water District, Mashpee Water District, and Otis ANG Base. A complete listing of water withdrawal permits is provided in Appendix C, Table C2 in the WQA (MADEP 2002a). There are no regulated wastewater dischargers in this segment.

DMF Designated Shellfish Growing Areas Status: Approved for 0.004 mi²; Prohibited for 0.096 mi² (Figure 1-1).

The DMF collected dry weather fecal coliform samples at two stations along this segment between March 1996 and September 2001. A total of 37 samples were collected. Fecal coliform values ranged from 1.9 to 51 cfu/100mL.

Waquoit Bay Segment MA96-21

This 1.54 mi² Class SA, ORW segment extends from the mouths of Seapuit, Quashnet, Little, and Great Rivers to the confluence with Vineyard Sound in Falmouth. The recharge area for this segment includes the recharge area for Quashnet River (Segment MA96-20); therefore, the water withdrawals from the Quashnet River may also impact this segment. There are no NPDES regulated discharges in the recharge area of this segment.

DMF Designated Shellfish Growing Areas Status: Approved (Figure 1-1).

Herring River Segment MA96-22

This 0.1 mi² Class SA segment extends from the outlet of the reservoir northwest of Neck Road to the river's mouth at Nantucket Sound in Harwich. The Herring River recharge area contains 256.58 acres of cranberry bog open space. A conservative estimate of water use by this bog area is 2.29 mgd. The Harwich Water Department is permitted to withdraw water from this segment. A complete listing of water withdrawal permits is provided in Appendix C, Table C2 in the CCWQA (MADEP 2002a). There are no regulated wastewater dischargers in this segment.

DMF Designated Shellfish Growing Areas Status: Conditionally Approved for 0.04 mi²; Prohibited for 0.04 mi² (Figure 1-1).

The DMF collected dry weather fecal coliform samples at three stations along this segment between January 1996 and August 2001. A total of 93 samples were collected. Fecal coliform values ranged from 1.9 to 51 cfu/100mL.

Saquatucket Harbor Segment MA96-23

This 0.02 mi² Class SA segment runs from south of Route 28 to the confluence with Nantucket Sound in Harwich. The Saquatucket Harbor recharge area contains 33.34 acres of cranberry bog open space. A conservative estimate of water use by this bog area is 0.30 mgd. There are no regulated withdrawals or NPDES regulated discharges in the recharge area of this segment.

DMF Designated Shellfish Growing Areas Status: Conditionally Approved for 0.01 mi²; Prohibited for 0.01 mi² (Figure 1-1).

The DMF collected dry weather fecal coliform samples at three stations along this segment between March 1996 and August 2001. A total of 116 samples were collected. Fecal coliform values ranged from 1.9 to 51 cfu/100mL.

Mashpee River Segment MA96-24

This 0.1 mi² Class SA segment extends from Quinaquisset Avenue to the river's mouth at Popponesset Bay in Mashpee. The Mashpee River recharge area contains 0.29 acres of cranberry bog open space. A conservative estimate of water use by this bog area is 0.003 mgd. The Quashnet Valley Golf Course is permitted to withdraw water from this segment. A complete listing of water withdrawal permits is provided in Appendix C, Table C2 in the CCWQA (MADEP 2002a). There are no regulated wastewater dischargers in this segment. However the Town of Mashpee is in the process of applying for a NPDES permit for the MS4.

DMF Designated Shellfish Growing Areas Status: Conditionally Approved for 0.04 mi²; Prohibited for 0.06 mi² (Figure 1-1).

The DMF collected dry weather fecal coliform samples at four stations along this segment between March 1996 and March 2001. A total of 80 samples were collected. Fecal coliform values ranged from 1.9 to 51 cfu/100mL.

Little Namskaket Creek Segment MA96-26

This 0.02 mi² Class SA, ORW segment extends from the creek's source to its mouth at Cape Cod Bay in Orleans. There are no regulated withdrawals or NPDES regulated discharges in the recharge area of this segment.

DMF Designated Shellfish Growing Areas Status: Prohibited (Figure 1-1).

The DMF collected dry weather fecal coliform samples at two stations along this segment between July 1997 and July 1998. A total of nine samples were collected. Fecal coliform values ranged from 1.9 to 18 cfu/100mL.

Namskaket Creek Segment MA96-27

This 0.01 mi² Class SA, ORW segment extends from the outlet of an unnamed pond north of Route 6A in Orleans to the creek's mouth at Cape Cod Bay in Brewster/Orleans. The Namskaket Creek recharge area contains 7.15 acres of cranberry bog open space. A conservative estimate of water use by this bog area is 0.06 mgd. A complete listing of water withdrawal permits is provided in Appendix C, Table C2 in the CCWQA (MADEP 2002a). There are no NPDES regulated discharges in the recharge area of this segment.

DMF Designated Shellfish Growing Areas Status: Prohibited (Figure 1-1).

The DMF collected dry weather fecal coliform samples at two stations along this segment between July 1997 and July 1998. A total of ten samples were collected. Fecal coliform values ranged from 1.9 to 11 cfu/100mL.

Provincetown Harbor Segment MA96-29

This 3.82 mi² Class SA segment includes the waters bounded by the shoreline and a line drawn from the tip of Long Point to Beach Point Beach in Provincetown. There are no regulated withdrawals or NPDES regulated discharges in the recharge area of this segment.

DMF Designated Shellfish Growing Areas Status: Approved for 3.04 mi²; Conditionally Approved for 0.33 mi²; Prohibited for 0.40 mi² (Figure 1-1).

The DMF collected dry weather fecal coliform samples at 11 stations along this segment between February 1996 and August 2001. A total of 228 samples were collected. Fecal coliform values ranged from 1.9 to 51 cfu/100mL.

Scorton Creek Segment MA96-30

This 0.05 mi² Class SA segment extends from Jones Lane to the creek's mouth at Cape Cod Bay in Sandwich. The Scorton Creek recharge area contains 86.01 acres of cranberry bog open space. A conservative estimate of water use by this bog area is 0.77 mgd. The following are permitted to withdraw water from this segment: Sandwich Water District, Sandwich Hollows Golf Course, and the Department of Fisheries and Wildlife. A complete listing of water withdrawal permits is provided in Appendix C, Table C2 in the CCWQA (MADEP 2002a). There are no regulated wastewater

dischargers in this segment; However the Town of Sandwich is in the process of applying for a NPDES permit for the MS4.

DMF Designated Shellfish Growing Areas Status: Prohibited (Figure 1-1).

Pamet River Segment MA96-31

This 0.2 mi² Class SA river segment extends from Route 6 to the river's mouth at Cape Cod Bay (including Pamet Harbor) in Truro. There are no regulated withdrawals or NPDES regulated discharges in the recharge area of this segment.

DMF Designated Shellfish Growing Areas Status: Conditionally Approved for 0.15 mi²; Prohibited for 0.05 mi² (Figure 1-1).

The DMF collected dry weather fecal coliform samples at nine stations along this segment between January 1996 and April 2001. A total of 164 samples were collected. Fecal coliform values ranged from 1.9 to 51 cfu/100mL.

Duck Creek Segment MA96-32

This 0.1 mi² Class SA segment extends from Cannon Hill to Shirttail Point in Wellfleet. There are no regulated withdrawals or NPDES regulated discharges in the recharge area of this segment.

DMF Designated Shellfish Growing Areas Status: Approved for 0.02 mi²; Conditionally Approved for 0.076 mi²; Prohibited for 0.004 mi² (Figure 1-1).

The DMF collected dry weather fecal coliform samples at four stations along this segment between January 1996 and August 2001. A total of 188 samples were collected. Fecal coliform values ranged from 1.9 to 51 cfu/100mL.

Herring River Segment MA96-33

This 0.7 mi² Class SA, ORW segment extends from Griffin Island to Wellfleet Harbor in Wellfleet. There are no regulated withdrawals or NPDES regulated discharges in the recharge area of this segment.

DMF Designated Shellfish Growing Areas Status: Conditionally Approved for 0.41 mi²; Restricted for 0.15 mi²; Prohibited for 0.01 mi² (Figure 1-1).

The DMF collected dry weather fecal coliform samples at 11 stations along this segment between March 1996 and August 2001. A total of 404 samples were collected. Fecal coliform values ranged from 1.9 to 312 cfu/100mL.

Wellfleet Harbor Segment MA96-34

This 7.27 mi² Class SA segment includes the waters north of a line drawn from Jeremy Point to Sunken Meadow (excluding the estuaries of Herring River, Duck Creek, and Blackfish Creek). There are no regulated withdrawals or NPDES regulated discharges in the recharge area of this segment.

DMF Designated Shellfish Growing Areas Status: Approved for 7.25 mi²; Prohibited for 0.02 mi² (Figure 1-1).

Chase Garden Creek Segment MA96-35

This 0.2 mi² Class SA segment extends from its source west of Route 6A in Dennis to the creek's mouth at Cape Cod Bay in Dennis/Yarmouth. The Chase Garden Creek recharge area contains 16.29 acres of cranberry bog open space. A conservative estimate of water use by this bog area is 0.15 mgd. King's Way Golf Course has two permitted wells that withdraw water from this recharge area. A complete listing of water withdrawal permits is provided in Appendix C, Table C2 in the CCWQA (MADEP 2002a). Aquaculture Research Corporation has a permit to discharge into this segment. The Town of Dennis and Yarmouth are in the process of applying for a NPDES permit for their MS4.

DMF Designated Shellfish Growing Areas Status: Conditionally Approved (Figure 1-1).

The DMF collected dry weather fecal coliform samples at six stations along this segment between January 1996 and June 2001. A total of 144 samples were collected. Fecal coliform values ranged from 1.9 to 51 cfu/100mL.

Lewis Bay Segment MA96-36

This 1.35 mi² Class SA segment includes Pine Island Creek and Uncle Roberts Cove and extends to the confluence with Nantucket Sound in Yarmouth. The Lewis Bay recharge area contains 91.41 acres of cranberry bog open space. A conservative estimate of water use by this bog area is 0.82 mgd. The following are permitted to withdraw water from this segment: Barnstable Water Company, Yarmouth Water Department, Barnstable Fire District, and Bayberry Hills Golf Course. A complete listing of water withdrawal permits is provided in Appendix C, Table C2 in the CCWQA (MADEP 2002a). There are no regulated wastewater dischargers in this segment. However the Town of Yarmouth is in the process of applying for a NPDES permit for the MS4.

DMF Designated Shellfish Growing Areas Status: Approved for 1.27 mi²; Conditionally Approved for 0.08 mi² (Figure 1-1).

The DMF collected dry weather fecal coliform samples at ten stations along this segment between January 1996 and September 2001. A total of 369 samples were collected. Fecal coliform values ranged from 1.9 to 67 cfu/100mL.

Mill Creek Segment MA96-37

This 0.09 mi² Class SA segment extends from Keveny/Mill Lane north to the confluence with Cape Cod Bay in Barnstable/Yarmouth. The Barnstable Harbor recharge area includes the Mill Creek recharge area; therefore, withdrawals from the Barnstable Harbor recharge area may also impact this segment. A complete listing of water withdrawal permits is provided in Appendix C, Table C2 in the CCWQA (MADEP 2002a). There are no regulated wastewater dischargers in this segment. However the Towns of Barnstable and Yarmouth are in the process of applying for a NPDES permit for the MS4.

DMF Designated Shellfish Growing Areas Status: Prohibited (Figure 1-1).

Parkers River Segment MA96-38

This 0.05 mi² Class SA segment extends from the outlet of Seine Pond to the river's mouth at Nantucket Sound in Yarmouth. The Parkers River recharge area contains 105.29 acres of cranberry bog open space. A conservative estimate of water use by this bog area is 0.94 mgd. The Yarmouth Water Department and the Bayberry Hills Golf Course are permitted to withdraw water from this segment. A complete listing of water withdrawal permits is provided in Appendix C, Table C2 in the CCWQA (MADEP 2002a). There are no regulated wastewater dischargers in this segment. However the Town of Yarmouth is in the process of applying for a NPDES permit for the MS4.

DMF Designated Shellfish Growing Areas Status: Approved for 0.008 mi²; Conditionally Approved for 0.015 mi² (Figure 1-1).

The DMF collected dry weather fecal coliform samples at four stations along this segment between January 1996 and June 2001. A total of 179 samples were collected. Fecal coliform values ranged from 1.9 to 51 cfu/100mL.

Red Lily Pond Segment MA96257

Red Lily Pond is 4.4 acres and is located in Barnstable.

Information regarding the segments described below can be found in the “*Buzzards Bay Watershed 2000 Water Quality Assessment Report*” (MADEP 2003b).

Cape Cod Canal Segment MA95-14

This is a 1.13 mi² Class SB waterbody. The Canal connects Buzzards Bay and Cape Cod Bay. Two vessel sewage pump-out boats are located in Bourne and Sandwich. Mirant Canal, LLC has two wells in this segment and five NPDES discharge outfalls. Mirant Canal, LLC discharges condenser cooling water, intake screen and flume flushing water, floor and equipment drains, waste system blowdown and demineralizer and condensate polisher waste waters. Massachusetts Maritime Academy has a NPDES permit to discharge treated sanitary waste, untreated boiler water blowdown and treated swimming pool discharge via two outfalls. Bourne and Sandwich are in the process of applying for NPDES permits for their MS4s.

DMF Designated Shellfish Growing Areas Status: Approved for 0.49 mi²; Prohibited for 0.33 mi² (Figure 1-1).

Eel Pond Segment MA95-48

This 0.03 mi² Class SA salt water pond discharges into the Back River. There are no known withdrawals or dischargers in this segment other than MS4s. Bourne is in the process of applying for a NPDES permit for their MS4.

DMF Designated Shellfish Growing Areas Status: Conditionally Approved (Figure 1-1).

Back River Segment MA95-47

This 0.08 mi² Class SA waterbody flows from the outlet of a small unnamed pond (downstream of Mill Pond) to its confluence with Phinneys Harbor. The Lobster Trap Company has a permit to discharge treated wastewater. Bourne is in the process of applying for a NPDES permit for their MS4.

DMF Designated Shellfish Growing Areas Status: Conditionally Approved for much of the segment and Prohibited for a small portion (see BBWQA, DMF website for growing areas BB47.1, BB47.2, BB47.20 and BB47.3 for more specific information at <http://www.mass.gov/dfwele/dmf/programsandprojects/dsga.htm#shelsani>).

Phinneys Harbor Segment MA95-15

This 0.73 mi² Class SA waterbody extends from the confluence with the Back River to its mouth at Buzzards Bay. A long dike to Hog and Mashnee Islands partially encloses the harbor. There are no known withdrawals or dischargers in this segment other than MS4s. Bourne is in the process of applying for a NPDES permit for their MS4.

DMF Designated Shellfish Growing Areas Status: Approved for 0.58 mi²; Conditionally Approved for 0.15 mi² (Figure 1-1).

Pocasset River Segment MA95-16

This is a 0.05 mi² Class SA, Outstanding Resource Water segment. The Bourne Water District has four withdrawal points in this segment. Bourne is in the process of applying for a NPDES permit for their MS4.

DMF Designated Shellfish Growing Areas Status: Prohibited (Figure 1-1).

Pocasset Harbor Segment MA95-17

This 0.33 mi² Class SA waterbody flows from the confluence with Red Brook Harbor to the mouth at Buzzards Bay. The Pocasset Golf Club has a water withdrawal in this segment. The Pocasset Harbor recharge area contains 3.64 acres of cranberry bog open space. A conservative estimate of water use by the bogs in this segment is 0.03 MGD. Bourne is in the process of applying for a NPDES permit for their MS4.

DMF Designated Shellfish Growing Areas Status: Approved for 0.20 mi²; Conditionally Approved for 0.13 mi² (Figure 1-1).

Red Brook Harbor Segment MA95-18

This 0.91 mi² Class SA waterbody flows from the confluence with Pocasset Harbor to its mouth at Buzzards Bay. The Bourne Water District has five withdrawal points in this segment. The Red Brook Harbor water recharge area contains 91.12 acres of cranberry bog open space. A conservative estimate of water use by the bogs in this segment is 0.81 MGD. Bourne is in the process of applying for a NPDES permit for their MS4.

DMF Designated Shellfish Growing Areas Status: Approved for 0.80 mi²; Conditionally Approved for 0.11 mi² (Figure 1-1).

Herring Brook Segment MA95-21

This 0.01 mi² Class SA waterbody flows from its headwaters located northeast of Dale Drive and west of Route 28A to its mouth at Buzzards Bay. There are no known water withdrawals or discharges in this segment other than MS4s. Falmouth is in the process of applying for a NPDES permit for its MS4.

DMF Designated Shellfish Growing Areas Status: Prohibited (Figure 1-1).

Harbor Head Segment MA95-46

This 0.02 mi² Class SA waterbody is located south of the confluence with West Falmouth Harbor at Chappaquoit Road. There are no known water withdrawals or discharges in this segment other than MS4s. Falmouth is in the process of applying for a NPDES permit for its MS4.

DMF Designated Shellfish Growing Areas Status: Restricted (Figure 1-1).

West Falmouth Harbor Segment MA95-22

This 0.29 mi² Class SA waterbody extends from the confluence with Harbor Head to the mouth at Buzzards Bay. The Falmouth Water Department has a water withdrawal permit. Falmouth is in the process of applying for a NPDES permit for its MS4.

DMF Designated Shellfish Growing Areas Status: Approved for 0.09 mi²; Conditionally Approved for 0.20 mi² (Figure 1-1).

Great Sippewisset Creek Segment MA95-23

This 0.03 mi² Class SA creek extends from the outlet of Beach Pond to the mouth at Buzzards Bay. The Falmouth Water Department is permitted to withdraw from the Long Pond Reservoir and the Mares Pond Well. Falmouth is in the process of applying for a NPDES permit for its MS4.

DMF Designated Shellfish Growing Areas Status: Prohibited (Figure 1-1).

Little Sippewisset Marsh Segment MA95-24

This 0.02 mi² Class SA waterbody extends from its headwaters north of Sippewisset Road to the mouth at Buzzards Bay. Falmouth Water Department is permitted to withdraw water from the Long Pond Reservoir. Falmouth is in the process of applying for a NPDES permit for its MS4.

DMF Designated Shellfish Growing Areas Status: Prohibited (Figure 1-1).

Quissett Harbor Segment MA95-25

This 0.17 mi² Class SA waterbody is landward of a line drawn between The Knob and Gansett Point. Woods Hole Golf Club is permitted to withdraw from two wells. Falmouth is in the process of applying for a NPDES permit for its MS4.

DMF Designated Shellfish Growing Areas Status: Approved for 0.1 mi²; Conditionally Approved for 0.05 mi² (Figure 1-1).

Other Segments

The following segments are listed on the *2002 List* for pathogen impairment but are not discussed in the “*Cape Cod Watershed Water Quality Assessment Report*” or “*Buzzards Bay Watershed 2000 Water Quality Assessment Report*”: Information regarding water withdrawals, NPDES discharges and indicator bacteria data were not available for these segments. Pathogen TMDLs have been completed and approved for the Frost Fish Creek (MA96-49; MADEP 2004a) and Muddy Creek (MA96-51; MADEP 2004b) segments and are therefore not discussed in this TMDL.

Popponesset Creek Segment MA96-39
Mill Creek Segment MA96-41
Taylors Pond Segment MA96-42
Harding Beach Pond Segment MA96-43
Bucks Creek Segment MA96-44
Oyster Pond Segment MA96-45
Oyster Pond River Segment MA96-46
Ryders Cove Segment MA96-50
Perch Pond Segment MA96-53

Great Pond Segment MA96-54
Great Pond Segment MA96-55
Bournes Pond Segment MA96-57
Hamblin Pond Segment MA96-58
Little River Segment MA96-61
Oyster Pond Segment MA96-62
Cotuit Bay Segment MA96-63
Seapuit River Segment MA96-64
North Bay Segment MA96-66

5.0 Potential Sources

The Cape Cod watershed has 68 segments, located throughout the watershed, that are listed as pathogen impaired and requiring a TMDL. These segments represent 70.0% of the estuary area and <1% of the lake area assessed. Sources of indicator bacteria in the Cape Cod watershed are many and varied. A significant amount of work has been done in the last decade to improve the water quality in the Cape Cod watershed.

Largely through the efforts of the Cape and Islands outreach organizations and the MADEP field staff, numerous point and non-point sources of pathogens have been identified. A list of Cape and Islands outreach organizations is provided by the Woods Hole Oceanographic Institution (WHOI SeaGrant) on the worldwide web at <http://www.whoi.edu/seagrant/Resources/DirCapel/Index.html>. Table 5-1 summarizes the river segments impaired due to measured fecal coliform contamination and identifies some of the suspected and known sources.

Some dry weather sources include:

- leaking sewer pipes,
- storm water drainage systems (illicit connections of sanitary sewers to storm drains),
- failing septic systems,
- wildlife including birds,
- recreational activities, and
- illicit boat discharges.

Some wet weather sources include:

- wildlife and domesticated animals (including pets),
- storm water runoff including municipal separate storm sewer systems (MS4), and
- sanitary sewer overflows (SSOs).

It is difficult to provide accurate quantitative estimates of indicator bacteria contributions from the various sources in the Cape Cod watershed because many of the sources are diffuse and intermittent, and extremely difficult to monitor or accurately model. Therefore, a general level of quantification according to source category is provided (e.g., Tables 5-2 and 5-3). This approach is suitable for the TMDL analysis because it indicates the magnitude of the sources and illustrates the need for controlling them. Additionally, many of the sources (failing septic systems, leaking sewer pipes, sanitary sewer overflows, and illicit sanitary sewer connections) are prohibited, because they indicate a potential health risk and, therefore, must be eliminated. However, estimating the magnitude of overall indicator bacteria loading (the sum of all contributing sources) is achieved for wet and dry conditions using the extensive ambient data available that define baseline conditions (see segment summary information, “*Atlas of Stormwater Discharges in the Buzzards Bay Watershed*”, BBWQA and CCWQA).

Table 5-1. Some of the Potential Sources of Bacteria in Pathogen Impaired Segments in the Cape Cod Watershed.

Segment ID	Segment Name	Potential Sources
MA95-48	Eel Pond	MS4, on-site treatment systems (septic systems)
MA95-47	Back River	MS4, on-site treatment systems (septic systems)
MA95-15	Phinneys Harbor	On-site treatment systems (septic systems), highway/road runoff
MA95-16	Pocasset River	On-site treatment systems (septic systems), road runoff, MS4
MA95-17	Pocasset Harbor	On-site treatment systems (septic systems), highway/road MS4
MA95-18	Red Brook Harbor	On-site treatment systems (septic systems), highway/road MS4
MA95-21	Herring Brook	On-site treatment systems (septic systems)
MA95-46	Harbor Head	On-site treatment systems (septic systems), highway/road runoff, MS4
MA95-22	West Falmouth Harbor	On-site treatment systems (septic systems), highway/road runoff, MS4
MA95-23	Great Sippewisset Creek	On-site treatment systems (septic systems), highway/road runoff
MA95-24	Little Sippewisset Marsh	On-site treatment systems (septic systems), highway/road runoff
MA95-25	Quissett Harbor	On-site treatment systems (septic systems), road runoff

Specific sources for the remaining impaired segments are unknown

MS4 = Municipal Separate Storm Water Sewer System – community storm water drainage system

Sanitary Waste

Leaking sewer pipes, illicit sewer connections, sanitary sewer overflows (SSOs), and failing septic systems represent a direct threat to public health since they result in discharge of partially treated or untreated human wastes to the surrounding environment. Quantifying these sources is extremely speculative without direct monitoring of the source because the magnitude is directly proportional to the volume of the source and its proximity to the surface water. Typical values of fecal coliform in untreated domestic wastewater range from 10^4 to 10^6 MPN/100mL (Metcalf and Eddy 1991).

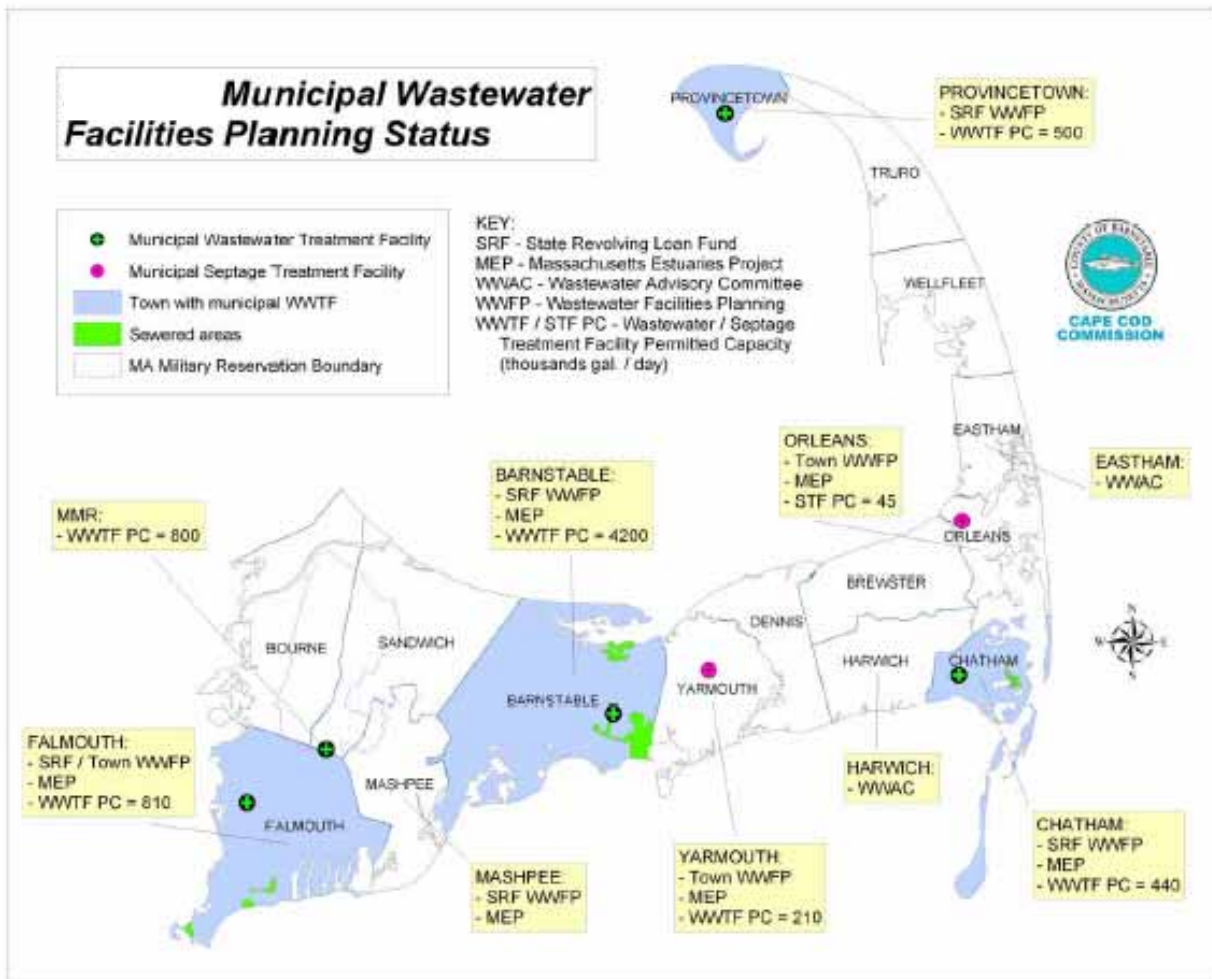
Illicit sewer connections into storm drains result in direct discharges of sewage via the storm drainage system outfalls. The existence of illicit sewer connections to storm drains is well documented in many urban drainage systems, particularly older systems that may have once been combined. It is probable that numerous illicit sewer connections exist in storm drainage systems serving the older developed portions of the basin.

Monitoring of storm drain outfalls during dry weather is needed to document the presence or absence of sewage in the drainage systems. Approximately 62% of the Cape Cod watershed is classified as Urban Areas by the United States Census Bureau and is therefore subject to the Stormwater Phase II Final Rule that requires the development and implementation of an illicit discharge detection and elimination plan. See Section 7.0 of this TMDL for information regarding illicit discharge detection guidance.

Septic systems designed, installed, operated and maintained in accordance with 310 CMR 15.000: Title 5, are not significant sources of fecal coliform bacteria. Studies demonstrate that wastewater located four feet below properly functioning septic systems contain on average less than one fecal coliform bacteria organism per 100 mL (Ayres Associates 1993). Failed or non-conforming septic systems, however, can be a major contributor of fecal coliform to the Cape Cod watershed, especially since most of the Cape's population relies on septic systems versus municipal sewer systems. Roughly eighty-five percent of the Cape Cod watershed's population has individual septic systems. Only four towns have WWTF with only a small portion of the Cape connected to the municipal sewer systems (Figure 5-1; Cape Cod Commission 2003). Wastes from failing septic systems enter surface waters either as direct overland flow or via groundwater. Wet weather events typically increase the rate of transport of pollutant loadings from failing septic systems to surface waters because of the wash-off effect from runoff and the increased rate of groundwater recharge.

Recreational use of waterbodies is a source of pathogen contamination. Swimmers themselves may contribute to bacterial impairment at swimming areas. When swimmers enter the water, residual fecal matter may be washed from the body and contaminate the water with pathogens. In addition, small children in diapers may contribute to contamination of the recreational waters. These sources are likely to be particularly important when the number of swimmers is high and the flushing action of waves or tides is low.

Figure 5-1. Municipal Wastewater Facilities on Cape Cod (Cape Cod Commission 2003)



Another potential source of pathogens is the discharge of sewage from vessels with onboard toilets. These vessels are required to have a marine sanitation device (MSD) to either store or treat sewage. When MSDs are operated or maintained incorrectly they have the potential to discharge untreated or inadequately treated sewage. For example, some MSDs are simply tanks designed to hold sewage until it can be pumped out at a shore-based pump-out facility or discharged into the water more than 3 miles from shore. Uneducated boaters may discharge untreated sewage from these devices into near-shore waters. In addition, when MSDs designed to treat sewage are improperly maintained or operated they may malfunction and discharge inadequately treated sewage. Finally, even properly operating MSDs may discharge sewage in concentrations higher than allowed in ambient water for fishing or shellfishing. Vessels are most likely to contribute to bacterial impairment in situations where large numbers of vessels congregate in enclosed environments with low tidal flushing. Many marinas and popular anchorages are located in such environments.

Wildlife and Pet Waste

Animals that are not pets can be a potential source of pathogens. Geese, gulls, and ducks are speculated to be a major pathogen source, particularly at lakes and storm water ponds where large resident populations have become established (Center for Watershed Protection 1999).

Household pets such as cats and dogs can be a substantial source of bacteria – as much as 23,000,000 colonies/gram, according to the Center for Watershed Protection (1999). A rule of thumb estimate for the number of dogs is ~1 dog per 10 people producing an estimated 0.5 pound of feces per dog per day. Using the 2000 census population for Barnstable county (Cape Cod Times 2001), this translates to an estimated 22,223 dogs in the watershed producing 11,112 pounds of feces per day. Uncollected pet waste is then flushed from the parks, beaches and yards where pets are walked and transported into nearby waterways during wet-weather.

Storm Water

Storm water runoff is another significant contributor of fecal coliform pollution. As discussed above, during rain events fecal matter from domestic animals and wildlife are readily transported to surface waters via the storm water drainage systems and/or overland flow. The natural filtering capacity provided by vegetative cover and soils is dramatically reduced as urbanization occurs because of the increase in impervious areas (i.e., streets, parking lots, etc.) and stream channelization in the watershed.

Extensive storm water data have been collected and compiled both locally and nationally (e.g., Tables 4-1, 4-2, 5-2 and 5-3) in an attempt to characterize the quality of storm water. Bacteria are easily the most variable of storm water pollutants, with concentrations often varying by factors of 10 to 100 during a single storm. Considering this variability, storm water bacteria concentrations are difficult to accurately predict. Caution must be exercised when using values from single wet weather grab samples to estimate the magnitude of bacteria loading because it is often unknown whether the sample is representative of the “true” mean. To gain an understanding of the magnitude of bacterial loading from storm water and avoid overestimating or underestimating bacteria loading, event mean concentrations (EMC) are often used. An EMC is the concentration of a flow proportioned sample throughout a storm event. These samples are commonly collected using an automated sampler which can proportion sample aliquots based on flow. Typical storm water event mean densities for

various indicator bacteria in Massachusetts watersheds and nationwide are provided in Tables 5-2 and 5-3. These EMCs illustrate that storm water indicator bacteria concentrations from certain land uses (i.e., residential) are typically at levels sufficient to cause water quality problems.

Table 5-2. Lower Charles River Basin Storm Water Event Mean Bacteria Concentrations (data summarized from USGS 2002) and Necessary Reductions to Meet Class B WQS.

Land Use Category	Fecal Coliform EMC (CFU/100 mL)	Number of Events	Class B WQS ¹	Reduction to Meet WQS (%)
Single Family Residential	2,800 – 94,000	8	10% of the samples shall not exceed 400 organisms/ 100 mL	2,400 – 93,600 (85.7 – 99.6)
Multifamily Residential	2,200 – 31,000	8		1,800 – 30,600 (81.8 – 98.8)
Commercial	680 – 28,000	8		280 – 27,600 (41.2 - 98.6)

¹ Class B Standard: Shall not exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms. Used 400 to illustrate required reductions since a geometric mean of the samples were not provided.

Table 5-3. Storm Water Event Mean Fecal Coliform Concentrations (as reported in MADEP 2002b; original data provided in Metcalf & Eddy, 1992) and Necessary Reductions to Meet Class B WQS.

Land Use Category	Fecal Coliform ¹ Organisms / 100 mL	Class B WQS ²	Reduction to Meet WQS (%)
Single Family Residential	37,000	10% of the samples shall not exceed 400 organisms/ 100 mL	36,600 (98.9)
Multifamily Residential	17,000		16,600 (97.6)
Commercial	16,000		15,600 (97.5)
Industrial	14,000		13,600 (97.1)

¹ Derived from NURP study event mean concentrations and nationwide pollutant buildup data (USEPA 1983).

² Class B Standard: Shall not exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms. Used 400 to illustrate required reductions since a geometric mean of the samples were not provided.

6.0 Pathogen TMDL Development

Section 303 (d) of the Federal Clean Water Act (CWA) requires states to place water bodies that do not meet the water quality standards on a list of impaired waterbodies. The most recent impairment list, *2002 List*, identifies 68 segments within the Cape Cod watershed for use impairment caused by excessive indicator bacteria concentrations.

The CWA requires each state to establish Total Maximum Daily Loads (TMDLs) for listed waters and the pollutant contributing to the impairment(s). TMDLs determine the amount of a pollutant that a waterbody can safely assimilate without violating the water quality standards. Both point and non-point pollution sources are accounted for in a TMDL analysis. Point sources of pollution (those discharges from discrete pipes or conveyances) subject to NPDES permits receive a waste load allocation (WLA) specifying the amount of pollutant each point source can release to the waterbody. Non-point sources of pollution (all sources of pollution other than point) receive a load allocation (LA) specifying the amount of a pollutant that can be released to the waterbody by this source. In accordance with the CWA, a TMDL must account for seasonal variations and a margin of safety, which accounts for any lack of knowledge concerning the relationship between effluent limitations and water quality. Thus:

$$\text{TMDL} = \text{WLAs} + \text{LAs} + \text{Margin of Safety}$$

Where:

WLA = Waste Load Allocation which is the portion of the receiving water's loading capacity that is allocated to each existing and future point source of pollution.

LA = Load Allocation which is the portion of the receiving water's loading capacity that is allocated to each existing and future non-point source of pollution.

This TMDL uses an alternative standards-based approach which is based on indicator bacteria concentrations, but considers the terms of the above equation. This approach is more in line with the way bacterial pollution is regulated (i.e., according to concentration standards) and achieves essentially the same result as if the equation were to be used.

6.1. Indicator Bacteria TMDL

Loading Capacity

The pollutant loading that a waterbody can safely assimilate is expressed as either mass-per-time, toxicity or some other appropriate measure (40 CFR § 130.2). Typically, TMDLs are expressed as total maximum daily loads. Expressing the TMDL in terms of daily loads is difficult to interpret given the very high numbers of indicator bacteria and the magnitude of the allowable load is dependent on flow conditions and, therefore, will vary as flow rates change. For example, a very high load of indicator bacteria are allowable if the volume of water that transports indicator bacteria is also high. Conversely, a relatively low load of indicator bacteria may exceed water quality standard if flow rates are low. Therefore, the MADEP believes it is appropriate to express indicator bacteria TMDLs in

terms of a concentration because the water quality standard is also expressed in terms of the concentration of organisms per 100 mL. Since source concentrations may not be directly added due to varying flow conditions, the TMDL equation is modified and reflects a margin of safety in the case of this pathogen concentration based TMDL. To ensure attainment with Massachusetts' WQS for indicator bacteria, all sources (at their point of discharge to the receiving water) must be equal to or less than the WQS for indicator organisms. For all the above reasons the TMDL is simply set equal to the concentration-based standard and may be expressed as follows:

$$\text{TMDL} = \text{State Standard} = \text{WLA}_{(p1)} = \text{LA}_{(n1)} = \text{WLA}_{(p2)} = \text{etc.}$$

Where:

$\text{WLA}_{(p1)}$ = allowable concentration for point source category (1)

$\text{LA}_{(n1)}$ = allowable concentration for nonpoint source category (1)

$\text{WLA}_{(p2)}$ = allowable concentration for point source category (2) etc.

For Class A surface waters (1) *the arithmetic mean of a representative set of fecal coliform samples shall not exceed 20 organisms per 100 mL*; and (2) *no more than 10% of the samples shall exceed 100 organisms per 100 mL*.

For Class B and Class SB and SA areas not designated for shellfishing (1) *the geometric mean of a representative set of fecal coliform samples shall not exceed 200 organisms per 100 mL*; and (2) *no more than 10% of the samples shall exceed 400 organisms per 100 mL*.

For Class SA open shellfish area surface waters (1) *the geometric mean of a representative set of fecal coliform samples shall not exceed 14 organisms per 100 mL*; and (2) *no more than 10% of the samples shall exceed 43 organisms per 100 mL*.

For Class SB open shellfish surface waters (1) *the geometric mean of a representative set of fecal coliform samples shall not exceed 88 organisms per 100 mL*; and (2) *no more than 10% of the samples shall exceed 260 organisms per 100 mL*.

For marine bathing beaches (BEACH Act standard) (1) *the geometric mean of a statistically sufficient number of samples (generally not less than 5 samples equally spaced over a 30-day period) shall not exceed 35 colonies per 100 mL* and (2) *no single enterococci sample shall exceed 104 colonies per 100 mL*.

For freshwater bathing beaches (MADPH standard, not yet adopted by the MADEP) (1) *the geometric mean of the most recent five enterococci levels within the same bathing season shall not exceed 33 colonies per 100 mL* and (2) *no single enterococci sample shall exceed 61 colonies per 100 mL*. – OR – (1) *the geometric mean of the most recent five E. coli levels within the same bathing season shall not exceed 126 colonies per 100 mL* and (2) *no single E. coli sample shall exceed 235 colonies per 100 mL*.

Waste Load Allocations (WLAs) and Load Allocations (LAs).

There are several WWTPs and other NPDES-permitted wastewater discharges within the Cape Cod watershed. NPDES wastewater discharge WLAs are set at the WQS. In addition there are numerous storm water discharges from storm drainage systems throughout the watershed. All piped discharges are, by definition, point sources regardless of whether they are currently subject to the requirements of NPDES permits. Therefore, a WLA set equal to the WQS will be assigned to the portion of the storm water that discharges to surface waters via storm drains.

WLAs and LAs are identified for all known source categories including both dry and wet weather sources for Class SA, Class SB, Class A and B segments within the Cape Cod watershed. Establishing WLAs and LAs that only address dry weather indicator bacteria sources would not ensure attainment of standards because of the significant contribution of wet weather indicator bacteria sources to WQS exceedances. Illicit sewer connections and deteriorating sewers leaking to storm drainage systems represent the primary dry weather point sources of indicator bacteria, while failing septic systems and possibly leaking sewer lines represent the non-point sources. Wet weather point sources include discharges from storm water drainage systems (including MS4s) and sanitary sewer overflows (SSOs). Wet weather non-point sources primarily include diffuse storm water runoff.

Table 6-1 presents the indicator bacteria WLAs and LAs for the various source categories. WLAs and LAs will change to reflect the revised indicator organisms (*E. coli* and enterococci) when the updated WQS have been finalized (See Section 3.0 of this report). Source categories representing discharges of untreated sanitary sewage to receiving waters are prohibited, and therefore, assigned WLAs and LAs equal to zero. There are several sets of WLAs and LAs, one for Class SA shellfish open waters, one for Class SB shellfish open waters, one for Class A waters, one for Class B and shellfish restricted Class SA and SB waters, one for no discharge areas, one for freshwater beaches, and one for marine beaches.

The TMDL should provide a discussion of the magnitudes of the pollutant reductions needed to attain the goals of the TMDL. Since accurate estimates of existing sources are generally unavailable, it is difficult to estimate the pollutant reductions for specific sources. For the illicit sources, the goal is complete elimination (100% reduction). However, overall wet weather indicator bacteria load reductions can be estimated using typical storm water bacteria concentrations, as presented in the BBWQA, CCWQA and the *Atlas of Stormwater Discharges in the Buzzards Bay Watershed*. These data indicate that up to two to three orders of magnitude (i.e., greater than 90%) reductions in storm water fecal coliform loadings generally will be necessary, especially in developed areas. This goal is expected to be accomplished through implementation of the best management practices (BMPs) associated with the Phase II control program in designated Urban Areas.

The expectation to attain WQS at the point of discharge is environmentally protective, and offers a practical means to identify and evaluate the effectiveness of control measures. In addition, this approach establishes clear objectives that can be easily understood by the public and individuals responsible for monitoring activities.

Table 6-1. Indicator Bacteria Waste Load Allocations (WLAs) and Load Allocations (LAs) for the Cape Cod Watershed.

Surface Water Classification	Pathogen Source	Waste Load Allocation Indicator Bacteria (CFU/100 mL)¹	Load Allocation Indicator Bacteria (CFU/100 mL)¹
A, B, SA, SB	Illicit discharges to storm drains	0	N/A
A, B, SA, SB	Leaking sanitary sewer lines	0	N/A
A, B, SA, SB	Failing septic systems	N/A	0
A	NPDES – WWTP	Not to exceed an arithmetic mean of 20 organisms in any set of representative samples, nor shall 10% of the samples exceed 100 organisms ²	N/A
A	Storm water runoff Phase I and II	Not to exceed an arithmetic mean of 20 organisms in any set of representative samples, nor shall 10% of the samples exceed 100 organisms ³	N/A
A	Direct storm water runoff not regulated by NPDES and livestock, wildlife & pets	N/A	Not to exceed an arithmetic mean of 20 organisms in any set of representative samples, nor shall 10% of the samples exceed 100 organisms ³
B & Not Designated for Shellfishing SA & SB	NPDES – WWTP	Shall not exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms ²	N/A
B & Not Designated for Shellfishing SA & SB	Storm water runoff Phase I and II	Not to exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms ³	N/A
B & Not Designated for Shellfishing SA & SB	Direct storm water runoff not regulated by NPDES and livestock, wildlife & pets	N/A	Not to exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms ³

Surface Water Classification	Pathogen Source	Waste Load Allocation Indicator Bacteria (CFU/100 mL)¹	Load Allocation Indicator Bacteria (CFU/100 mL)¹
SA Designated Shellfishing Areas	NPDES – WWTP	Not to exceed a geometric mean of 14 organisms in any set of representative samples, nor shall 10% of the samples exceed 43 organisms ²	N/A
SA Designated Shellfishing Areas	Storm water Runoff Phase I and II	Not to exceed a geometric mean of 14 organisms in any set of representative samples, nor shall 10% of the samples exceed 43 organisms ³	N/A
SA Designated Shellfishing Areas	Direct storm water runoff not regulated by NPDES and livestock, wildlife & pets	N/A	Not to exceed a geometric mean of 14 organisms in any set of representative samples, nor shall 10% of the samples exceed 43 organisms ³
SB Designated Shellfishing Areas	NPDES – WWTP	Not to exceed a geometric mean of 88 organisms in any set of representative samples, nor shall 10% of the samples exceed 260 organisms ²	N/A
SB Designated Shellfishing Areas	Storm water runoff Phase I and II	Not to exceed a geometric mean of 88 organisms in any set of representative samples, nor shall 10% of the samples exceed 260 organisms ³	N/A
SB Designated Shellfishing Areas	Direct storm water runoff not regulated by NPDES and livestock, wildlife & pets	N/A	Not to exceed a geometric mean of 88 organisms in any set of representative samples, nor shall 10% of the samples exceed 260 organisms ³
No Discharge Areas	Vessels – raw or treated sanitary waste	0	N/A
Marine Beaches ⁴	All Sources	Enterococci not to exceed a geometric mean of 35 colonies in a statistically significant number of samples, nor shall any single sample exceed 104 colonies	Enterococci not to exceed a geometric mean of 35 colonies in a statistically significant number of samples, nor shall any single sample exceed 104 colonies

Surface Water Classification	Pathogen Source	Waste Load Allocation Indicator Bacteria (CFU/100 mL) ¹	Load Allocation Indicator Bacteria (CFU/100 mL) ¹
Fresh Water Beaches ⁵	All Sources	<p>Enterococci not to exceed a geometric mean of 33 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 61 colonies</p> <p>OR</p> <p><i>E. coli</i> not to exceed a geometric mean of 126 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 235 colonies</p>	<p>Enterococci not to exceed a geometric mean of 33 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 61 colonies</p> <p>OR</p> <p><i>E. coli</i> not to exceed a geometric mean of 126 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 235 colonies</p>

N/A means not applicable

¹ Waste Load Allocation (WLA) and Load Allocation (LA) refer to fecal coliform densities unless specified in table.

² Or shall be consistent with the Waste Water Treatment Plant (WWTP) National Pollutant Discharge Elimination System (NPDES) permit.

³The expectation for WLAs and LAs for storm water discharges is that they will be achieved through the implementation of BMPs and other controls.

⁴ Federal Beaches Environmental Assessment and Coastal Health Act of 2000 (BEACH Act) Water Quality Criteria

⁵ Massachusetts Department of Public Health regulations (105 CMR Section 445)

Note: this table represents waste load and load reductions based on water quality standards current as of the publication date of these TMDLs, any future changes made to the Massachusetts water quality standards will become the governing water quality standards for these TMDLs.

This TMDL applies to the 66 pathogen impaired segments of the Cape Cod watershed that are currently listed on the CWA § 303(d) list of impaired waters. MADEP recommends however, that the information contained in this TMDL guide management activities for all other waters throughout the watershed to help maintain and protect existing water quality. For these non-impaired waters, Massachusetts is proposing “pollution prevention TMDLs” consistent with CWA § 303(d)(3).

The analyses conducted for the pathogen impaired segments in this TMDL would apply to the non-impaired segments, since the sources and their characteristics are equivalent. The waste load and/or load allocation for each source and designated use would be the same as specified herein. Therefore, the pollution prevention TMDLs would have identical waste load and load allocations based on the sources present and the designated use of the water body segment (see Table ES-1 and Table 6-1).

This Cape Cod watershed TMDL may, in appropriate circumstances, also apply to segments that are listed for pathogen impairment in subsequent Massachusetts CWA § 303(d) Integrated List of Waters. For such segments, this TMDL may apply if, after listing the waters for pathogen impairment and taking into account all relevant comments submitted on the CWA § 303(d) list, the Commonwealth determines with EPA approval of the CWA § 303(d) list that this TMDL should apply to future pathogen impaired segments.

6.2. Margin of Safety

This section addresses the incorporation of a Margin of Safety (MOS) in the TMDL analysis. The MOS accounts for any uncertainty or lack of knowledge concerning the relationship between pollutant loading and water quality. The MOS can either be implicit (i.e., incorporated into the TMDL analysis through conservative assumptions) or explicit (i.e., expressed in the TMDL as a portion of the loadings). This TMDL uses an implicit MOS, through inclusion of two conservative assumptions. First, the TMDL does not account for mixing in the receiving waters and assumes that zero dilution is available. Realistically, influent water will mix with the receiving water and become diluted below the water quality standard, provided that the receiving water concentration does not exceed the TMDL concentration. Second, the goal of attaining standards at the point of discharge does not account for losses due to die-off and settling of indicator bacteria that are known to occur.

6.3. Seasonal Variability

In addition to a Margin of Safety, TMDLs must also account for seasonal variability. Pathogen sources to Cape Cod waters arise from a mixture of continuous and wet-weather driven sources, and there may be no single critical condition that is protective for all other conditions. This TMDL has set WLAs and LAs for all known and suspected source categories equal to the Massachusetts WQS independent of seasonal and climatic conditions. This will ensure the attainment of water quality standards regardless of seasonal and climatic conditions. Controls that are necessary will be in place throughout the year, protecting water quality at all times. However, for discharges that do not affect shellfish beds, intakes for water supplies and primary contact recreation is not taking place (i.e., during the winter months) seasonal disinfection is permitted for NPDES point source discharges.

7.0 Implementation Plan

Setting and achieving TMDLs should be an iterative process, with realistic goals over a reasonable timeframe and adjusted as warranted based on ongoing monitoring. The concentrations set out in the TMDL represent reductions that will require substantial time and financial commitment to be attained. A comprehensive control strategy is needed to address the numerous and diverse sources of pathogens in the Cape Cod watershed.

Controls on several types of pathogen sources will be required as part of the comprehensive control strategy. Many of the sources in the Cape Cod watershed including sewer connections to drainage systems, leaking sewer pipes, sanitary sewer overflows, and failing septic systems, are prohibited and must be eliminated. Individual sources must be first identified in the field before they can be abated. Pinpointing sources typically requires extensive monitoring of the receiving waters and tributary storm water drainage systems during both dry and wet weather conditions. A comprehensive program is needed to ensure illicit sources are identified and that appropriate actions will be taken to eliminate them. The MADEP, MACZM, EPA, Cape Cod Commission and Cape and Island stewards have been successful in carrying out such monitoring, identifying sources, and, in some cases, mobilizing the responsible municipality and other entities to begin to take corrective actions.

Storm water runoff represents another major source of pathogens in the Cape Cod watershed, and the current level of control is inadequate for standards to be attained. Improving storm water runoff quality is essential for restoring water quality and recreational uses. At a minimum, intensive application of non-structural BMPs is needed throughout the watershed to reduce pathogen loadings as well as loadings of other storm water pollutants (e.g., nutrients and sediments) contributing to use impairment in the Cape Cod watershed. Depending on the degree of success of the non-structural storm water BMP program, structural controls may become necessary.

For these reasons, a basin-wide implementation strategy is recommended. The strategy includes a mandatory program for implementing storm water BMPs and eliminating illicit sources. The *“Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts”* was developed to support implementation of pathogen TMDLs. TMDL implementation-related tasks are shown in Table 7-1. The MADEP working with EPA and other team partners shall make every reasonable effort to assure implementation of this TMDL. These stakeholders can provide valuable assistance in defining hot spots and sources of pathogen contamination as well as the implementation of mitigation or preventative measures.

Table 7-1. Tasks

Task	Organization
Writing TMDL	MADEP
TMDL public meeting	MADEP
Response to public comment	MADEP
Organization, contacts with volunteer groups	MADEP/Cape Cod Commission
Development of comprehensive storm water management programs including identification and implementation of BMPs	Cape Cod Communities
Illicit discharge detection and elimination	Cape Cod Basin Communities with Cape Cod Commission
Leaking sewer pipes and sanitary sewer overflows	Cape Cod Communities
Inspection and upgrade of on-site sewage disposal systems as needed	Homeowners, Cape Cod Commission and Cape Cod Communities (Boards of Health)
Organize implementation; work with stakeholders and local officials to identify remedial measures and potential funding sources	MADEP, Cape Cod Commission, and Cape Cod Communities
Organize and implement education and outreach program	MADEP, Cape Cod Commission, and Cape Cod Communities
Write grant and loan funding proposals	Cape Cod Commission, Cape Cod Communities and Planning Agencies with guidance from MADEP
Inclusion of TMDL recommendations in Executive Office of Environmental Affairs (EOEA) Watershed Action Plan	EOEA
Surface Water Monitoring	MADEP and MACZM
Provide periodic status reports on implementation of remedial activities	EOEA and Cape Cod Commission

7.1. Summary of Activities within the Cape Cod Watershed

There are numerous active stewards of the Cape Cod watershed, these include:

- Barnstable Land Trust
- Brewster Ponds Water Quality Stewards
- Buzzards Bay Citizen Monitoring Program
- Cataumet Civic Associates
- Chatham Water Watchers
- Cotuit Waders
- Eastham Pond Stewards
- Falmouth Pond Watchers
- Garretts Pond Watchers
- Harwich Shellfish and Marine Water Quality Committee
- Nantucket Environmental Laboratory
- Mashpee Shellfish Department
- Orleans Water Quality Task Force
- Pleasant Bay Citizen Water Quality Monitoring Program
- Provincetown Harbor Water Quality Monitoring Program
- Shawme Pond Watershed Association
- Three Bays Water Quality Monitoring Program
- University of Massachusetts Cooperative Extension
- Wampanoag Tribe of Gay Head, Aquinnah
- Waquoit Bay National Estuarine Research Reserve
- Wequaquet Lake Protective Association
- Wheeler Road Association & Friends

Contact information for each of these groups can be obtained from the Massachusetts Water Watch Partnership Directory of Massachusetts Volunteer Monitoring Groups website (<http://www.umass.edu/tei/mwwp/groups.html>) as well as links to their respective websites, which provide details regarding past and on-going activities. These groups are generally involved in water quality sampling (may or may not be pathogen related) and outreach and education for residents within subwatersheds of Cape Cod.

Data supporting this TMDL indicate that indicator bacteria enter the Cape Cod watershed from a number of contributing sources, under a variety of conditions. Activities that are currently ongoing and/or planned to ensure that the TMDL can be implemented include and are summarized in the following subsections. The *“Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts”* provides additional details on the implementation of pathogen control measures summarized below as well as additional measures not provided herein, such as by-law, ordinances and public outreach and education.

7.2. Illicit Sewer Connections and Failing Infrastructure

Elimination of illicit sewer connections and identifying and repairing failing infrastructure are of extreme importance. Guidance for illicit discharge detection and elimination has been developed by EPA New England (USEPA 2004c) for the Lower Charles River. The guidance document provides a plan, available to all Commonwealth communities, to identify and eliminate illicit discharges (both dry and wet weather) to their separate storm sewer systems. Although originally prepared for the Charles River watershed it is applicable to all watersheds throughout the Commonwealth. Implementation of the protocol outlined in the guidance document satisfies the Illicit Discharge Detection and Elimination requirement of the NPDES program. A copy of the guidance document is provided in Appendix A.

7.3. Storm Water Runoff

Storm water runoff can be categorized in two forms 1) point source discharges and 2) non-point source discharges (includes sheet flow or direct runoff). Many point source storm water discharges are regulated under the NPDES Phase I and Phase II permitting programs when discharged to a Waters of the United States. Municipalities that operate regulated municipal separate storm sewer systems (MS4s) must develop and implement a storm water management plan (SWMP), which must employ and set measurable goals for the following six minimum control measures:

1. public education and outreach particularly on the proper disposal of pet waste,
2. public participation/involvement,
3. illicit discharge detection and elimination,
4. construction site runoff control,
5. post construction runoff control, and
6. pollution prevention/good housekeeping.

Portions of towns in this watershed are classified as Urban Areas by the United States Census Bureau and are subject to the Stormwater Phase II Final Rule. This rule requires the development and implementation of an illicit discharge detection and elimination plan.

The NPDES permit does not, however, establish numeric effluent limitations for storm water discharges. Maximum extent practicable (MEP) is the statutory standard that establishes the level of pollutant reductions that regulated municipalities must achieve. The MEP standard is a narrative effluent limitation that is satisfied through implementation of SWMPs and achievement of measurable goals.

Non-point source discharges are generally characterized as sheetflow runoff and are not categorically regulated under the NPDES program and can be difficult to manage. However, some of the same principles for mitigating point source impacts may be applicable. Individual municipalities not regulated under the Phase I or II should implement the exact same six minimum control measures minimizing storm water contamination.

7.4. Failing Septic Systems

Much of the Cape Cod basin relies on on-site waste water systems such as septic systems (see Figure 5-1). Septic system bacteria contributions to the Cape Cod watershed may be reduced in the future through septic system maintenance and/or replacement. Additionally, the implementation of Title 5, which requires inspection of private sewage disposal systems before property ownership may be transferred, building expansions, or changes in use of properties, will aid in the discovery of poorly operating or failing systems. Because systems which fail must be repaired or upgraded, it is expected that the bacteria load from septic systems will be significantly reduced in the future. Regulatory and educational materials for septic system installation, maintenance and alternative technologies are provided by the MADEP on the worldwide web at <http://www.mass.gov/dep/brp/wwm/t5pubs.htm>.

7.5. Wastewater Treatment Plants

WWTP discharges to groundwater are regulated by the MADEP Bureau of Resource Protection. Each WWTP has an effluent limit included in its groundwater discharge permit. Groundwater permits are available at <http://www.mass.gov/dep/brp/gw/gwhome.htm>.

7.6. Recreational Waters Use Management

Recreational waters receive pathogen inputs from swimmers and boats. To reduce swimmers' contribution to pathogen impairment, shower facilities can be made available, and bathers should be encouraged to shower prior to swimming. In addition, parents should check and change young children's diapers when they are dirty. Options for controlling pathogen contamination from boats include:

- petitioning the State for the designation of additional No Discharge Areas (NDAs);
- supporting installation of pump-out facilities for boat sewage;
- educating boat owners on the proper operation and maintenance of marine sanitation devices (MSDs); and
- encouraging marina owners to provide clean and safe onshore restrooms and pump-out facilities.

The entire Buzzards Bay and select areas surrounding the Cape have already been established as a no discharge areas (NDA). This designation by the Commonwealth of Massachusetts and approved by the EPA provides protection of this area by a Federal Law which prohibits the release of raw or treated sewage from vessels into navigable waters of the U.S. The law is enforced by the Massachusetts Environmental Police. The MACZM and Massachusetts Environmental Law Enforcement are actively pursuing an amendment to State regulations allowing for the institution of fines up to \$2000 for violations within a NDA (USEPA 2004a).

7.7. Funding/Community Resources

A complete list of funding sources for implementation of non-point source pollution is provided in Section VII of the Massachusetts Nonpoint Source Management Plan Volume I (MADEP 2000b) available on line at <http://www.mass.gov/dep/brp/wm/nonpoint.htm>. This list includes specific programs available for non-point source management and resources available for communities to

manage local growth and development. The State Revolving Fund (SRF) provides low interest loans to communities for certain capital costs associated with building or improving wastewater treatment facilities. In addition, many communities in Massachusetts sponsor low cost loans through the SRF for homeowners to repair or upgrade failing septic systems.

7.8. Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts

For a more complete discussion on ways to mitigate pathogen water pollution, see the “*Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts*” accompanying this document.

8.0 Monitoring Plan

The long term monitoring plan for the Cape Cod watershed includes several components:

1. continue with the current monitoring of the Cape Cod watershed (DMF and other watershed stewards),
2. continue with MADEP watershed five-year cycle monitoring,
3. monitor areas within the watershed where data are lacking or absent to determine if the waterbody meets the use criteria,
4. monitor areas where BMPs and other control strategies have been implemented or discharges have been removed to assess the effectiveness of the modification or elimination,
5. assemble data collected by each monitoring entity to formulate a concise report where the basin is assessed as a whole and an evaluation of BMPs can be made, and
6. add/remove/modify BMPs as needed based on monitoring results.

The monitoring plan is an ever changing document that requires flexibility to add, change or delete sampling locations, sampling frequency, methods and analysis. At the minimum, all monitoring should be conducted with a focus on:

- capturing water quality conditions under varied weather conditions;
- establishing sampling locations in an effort to pin-point sources;
- researching new and proven technologies for separating human from animal bacteria sources; and
- assessing efficacy of BMPs

9.0 Reasonable Assurances

Reasonable assurances that the TMDL will be implemented include both enforcement of current regulations, availability of financial incentives including low or no-interest loans to communities for wastewater treatment facilities through the State Revolving Fund (SRF), and the various local, state and federal programs for pollution control. Storm water NPDES permit coverage will address discharges from municipal owned storm water drainage systems. Enforcement of regulations controlling non-point discharges includes local enforcement of the states Wetlands Protection Act and Rivers Protection Act; Title 5 regulations for septic systems and various local regulations including zoning regulations. Financial incentives include Federal monies available under the CWA Section 319 NPS program and the CWA Section 604 and 104b programs, which are provided as part of the Performance Partnership Agreement between MADEP and the EPA. Additional financial incentives include state income tax credits for Title 5 upgrades, and low interest loans for Title 5 septic system upgrades through municipalities participating in this portion of the state revolving fund program.

10.0 Public Participation

To be added later....

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Appendix A

Lower Charles River Illicit Discharge Detection & Elimination (IDDE)
Protocol Guidance for Consideration - November 2004